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SURVEY of MATERIALS INFORMATION CENTERS

C-E-I-R

ASD-TDR-63-395

SURVEY OF MATERIALS INFORMATION CENTERS

TECHNICAL DOCUMENTARY REPORT NO. ASD-TDR-63-395

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Directorate of Materials and Processes
Aeronautical Systems Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

Project No. 7381, Task No. 738103

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C-E-I-R

FOREWORD

This report was prepared by C-E-I-R, INC., Arlington 2, Virginia, on Air Force Contract No. AF 33(657)-8780 under Task No. 7381, "Materials Application," of Project No. 738103, "Data Collection and Correlation." The work was administered under the direction of the Directorate of Materials and Processes, Metals and Ceramics Lab, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, with Mr. Harold Thompson acting as Project Engineer.

The report covers work conducted from August 1962 to March 1963.

It is desired to give credit for cooperation and assistance in the preparation of this survey to:

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Mr. A. J. Belfour	Belfour Engineering Company
Dr. C. L. Bernier	ASTIA *
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Mr. H. T. Johnson	Hughes Aircraft Company
Mr. E. Pronko	NSF
Mr. H. Thompson	Aeronautical Systems Division
Dr. Y. S. Touloukian	Purdue University

* Armed Forces Technical Information Agency (ASTIA) is now the Defense Document Center (DDC) retroactive 10 May 1963. Throughout this report reference is made to ASTIA.

ABSTRACT

This survey was undertaken to give the Directorate of Materials and Processes, WPAFB, Ohio and its members factual data on the scope, level, methods and information services of four special materials information centers.

A concentrated analysis of the systems was made through personal visits and examination of various reports either published by the centers or relating to their field of endeavor. Continued support of existing technical information centers and further analysis of users' needs are the principal recommendations of this study. These recommendations are based on fully substantiated conclusions as to need for, feasibility of, and outlook toward adequate performance of the centers studied.

This Technical Documentary Report has been reviewed and is approved.

D. A. SHINN
Chief, Materials Information Branch
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Directorate of Materials and Processes

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I. INTRODUCTION

This is a final report culminating six months of effort on a survey and analysis of certain materials information systems developed and maintained with support from Materials Central, Wright-Patterson Air Force Base, Ohio.

Today more than ever before the accessibility of information is of prime concern, particularly with respect to national defense activities.

W. G. Alexander, in a report before the Armed Forces Communications Electronics Association on 15 November 1960, estimated that it is costing the United States upwards to one billion dollars a year because of inadequate information retrieval. Although dollar cost is not so important as the time dimension in obtaining information, it does point up the monumental need for technological finesse in supplying information as well as a desire of the scientific and technical community in seeking it out.

There are a number of materials information centers forming a part of, and serving, industrial, educational and governmental organizations. This report, however, does not attempt to include all known sources of materials information. The contractual endeavor was designed to give a comprehensive report on the functions of four selected centers presently under contract to Materials Central, and a brief analysis of several other systems whose activities and interests paralleled those under consideration.

In this report a materials information center is defined as "an installation recording knowledge (i.e., selection, classification, evaluation indexing, storage and retrieval) of one or more types, groups or classes of materials and their properties."

There are many general and specialized information retrieval systems for recording knowledge. The input and interrogating languages separately range from binary codes through formal languages to English. Each system has its own reason for existence. But are the systems doing what they are designed to do? Just because they contain a large volume of material does not necessarily mean that a potential user has rapid access to any piece of information he wants. The elegance and sophistication incorporated into the structure of a system is not a measurement of its worth. Its true value can be measured only by the information it supplies and the use made of it. That is, the utility of an information retrieval system must be measured by drawing a balance between the cost and

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effort that the user must expend and the completeness and correctness of the information that he gets, as well as the convenience and speed with which he gets it. If a system does not rate high on this scale, then indeed, it would be punishing to use its information.

Perhaps it is not possible to be objective about information technology at this stage of development. But neither is it permissible at such a critical time in our nation's history to be wasteful in the extreme by solving problems that have already been solved. Where information is available it should be used. The users of information must be made aware of its sources. I addition, it must be rewarding and not punishing to have information for, in the words of C. N. Mooers:

> "Where rewards, instead of punishment, go with not using information, we can expect that any information retrieval system will be used only with reluctance. On the other hand, there are situations where the diligent finding and use of information is stressed and rewarded, and where failure to find or to use information is severely punished. In such places, we can expect retrieval systems to be actively used and we can expect pressure from the information users themselves for better systems. This has proved to be true in practice . . . ."

This survey then is an attempt to provide detailed information about the centers as they now exist within the industrial, educational, and governmental complex; the method and cost of operating them, the information they provide and the use made of them. Conclusions and recommendations are based strongly on user requirements. The summary comparison contains unit information on scope, organizational aspects, products and services, and operations. It has been edited and checked by the respective center directors. The figures used are essentially those made available by the respective centers.

The analysis and results of this report were prepared by C-E-I-R, INC., Washington, D. C. This organization bears full responsibility for the presentation and interpretation of the information obtained from the survey.

II. THE SURVEY

A. Basic Plan

Original plans for survey of materials information centers specified four major phases prior to final analysis and synthesis of a recommended future program. These phases --

literature search,
design and test of techniques and media for survey,
review of present systems documentation, and
field audit --

were implemented within limitations imposed by development status of systems under study and by availability of information.

B. Literature Search

An extensive body of current literature was reviewed for use in this study. ASTIA's documentation bibliography, updated by a new search, provided useful references. Survey reports were found covering recent state-of-the-art reviews by such organizations as the publishers of International Science and Technology, the National Bureau of Standards, National Science Foundation, American Management Association, and the American Documentation Institute, among others. Based on the apparent accomplishments and problem areas of information storage and retrieval, a set of general survey questions was developed for this study as set forth in the following paragraph. Reports on the number of technical information centers were used to verify the relevancy and general availability of information on these topics. However, little or no material appeared in the general literature concerning materials information centers of immediate interest to Aeronautical Systems Division. Accordingly, the initial questionnaire had to be tested during review of systems documentation and field audit.

C. Design and Test of Techniques and Media for Survey

The principal survey technique selected for this study was that of analytical review to develop details on experience, conclusions, and planning at each of the materials information centers and at Materials Central. The initial questionnaire, developed from literature survey and from review of available documentation, was as follows:

1. General

   a. Give a brief outline of data processing steps with a statement of principles involved in each step.

2. Literature

   a. What types of publications carry the majority of the articles of interest?

   b. How does the center procure literature?

   c. How is information extracted and evaluated?

   d. Approximately how many documents are in the system?

3. System

   a. How many people are used to maintain the system?

   b. What are their technical specialties?

   c. Is there any known compatibility between this system and others in existence?

   d. How is obsolete data removed from the system? What determines obsolescence? How complete is the system?

   e. What is the estimated reliability of information from the system?

   f. To what degree is ADP equipment used in the system?

   g. Are there plans for validating the system?

4. Services

   a. What types of services are provided and what is under development?

   b. Who uses the system and how are people encouraged to use it?

   c. What are the parameters of a customer's needs?

   d. In what form is the information presented?

   e. Is the system easy to use?

Early visits during field audit proved that the review would have to be completed as an ad hoc study, with entirely different areas of emphasis for each center. An additional set of questions was prepared to cover topics of general importance to all centers in order to supplement and standardize to some degree the information readily available. The additional questions follow:

1. Costs

   a. What cost figures are useful for control purposes? Is there a need for breakdowns such as: man-hours, dollars by labor class, equipment cost for the following:

      (1) acquisition
      (2) indexing
      (3) handling
      (4) search

   b. What are some measures of cost which are representative of center maintenance as for example: the number of man-hours expended versus --

      (1) number of index entries
      (2) number of data points extracted
      (3) number of documents indexed
      (4) original cost of studies indexed
      (5) cost of equivalent work if center would not exist?

   c. Do you think technical information centers should charge for their services? If so, do you think it reasonable to expect that they could earn sufficient income to maintain themselves?

   d. How could charges be structured supposing the answers were "yes" to the above?

   e. If each center had to rely solely on in-house sponsorship, what centers would continue in IR and to what extent could they operate?

   f. To what extent do annual contracts prohibit center planning and progress that would be possible in longer-term contracts?

   g. To achieve current status for your particular field of interest within two years, what increase in operating expenditures would be necessary?

2. Effectiveness

a. How can information centers be judged as to the effectiveness of their operations?

b. To what extent would the following factors be of interest in judging the effectiveness of a center:

(1) size of vocabulary as related to the optimum description
(2) depth of indexing as related to the collection scope
(3) size of collection as related to the extent of field of entries
(4) number of users as related to the potential number of users?

3. Usage

a. Should steps be taken to bring about further use of the potential for providing technical information?

b. If so, what specific steps should be taken and who should make them?

c. Specifically what usage do you envisage for your center and to what extent could the center do more?

d. To what extent do you presently have the manpower and facilities to implement the above?

e. Are you satisfied with the use that is made of your center?

f. What following functions are susceptible of decentralized operations and why?

(1) acquisition of documents
(2) indexing
(3) storage of documents and data
(4) processing of inquiries
(5) search of indexes
(6) processing of outputs

g. Which ones of the above are best in a centralized operation and why?

h. In what areas do you plan to use digital computers? Is this because there is a saving of man-power, time, and/or money?

i. What problems if any have you encountered with regard to proprietary rights and/or copyrights?

4. Coordination and Duplication

a. To what extent are you aware of any duplication with other centers?

b. How much of this is beneficial and how much is wasetful?

c. To what extent is there coordination among the centers?

d. If more is desirable, in what form should this coordination take place?

e. If more coordination is warranted why hasn't there been more?

f. What difficulties would be encountered if one tried to make his system compatible with another?

g. Under what conditions would compatibility be desirable?

5. Trends

a. What major obstacles face Information Retrieval?

b. What solutions do you foresee on the horizon for the above?

c. In what areas is mechanization needed in Information Retrieval?

Further guidelines for conduct of the study were received during a conference with Materials Information Branch personnel on 15 November 1962. These suggestions were incorporated into the study as outlined below:

1. Systems to be considered (primary interest)

a. Materials Central - University of Dayton

b. Thermophysical Properties Research Center - Purdue University

c. Electrical and Electronic Properties - Hughes Aircraft Company

d. Mechanical Properties - Belfour Engineering Company

2. What do we need in Materials Central Information System?

   a. Document Library

   b. Sources or source pertaining to specific information

3. Compatibility of systems in one of the above

   a. Is there compatibility?

   b. Is compatibility desirable? Why or why not?

   c. How can compatibility be accomplished?

4. Duplication of Effort

   a. Is there and what is it?

   b. Is it necessary or desirable?

   c. How can it be controlled or utilized?

5. Use made of systems

6. Relative operational costs of four systems

Other techniques and media were considered for use during the survey. Comparative methods for flow charting, format arrays, language analysis, user identification, activity measurement, and cost study were envisioned as desirable. However, two major factors prevented the use of conventional systems analysis techniques and required exercise of observation and judgment in lieu of precise definition and measurement. These factors are:

1. Existing materials information centers are in widely varying stages of development and implementation. None is fully operational in terms of their "chartered" objective, and none has arrived at a "final" system. Even where several years of operation have been completed, a change in available computer type and organizational status of the center was encountered. Since each center was started as an independent development project, the individual effort and original contributions on the part of each group resulted in differences of emphasis and even of evolutionary paths followed. This is natural and is not regarded as any weakness of the program.

2. Costs of complete, detailed systems documentation would exceed the funds available for this study. Such work is properly a part of the effort at each center, and increasing attention is being given to this necessary but somewhat neglected task. The argument against spending resources on such a task becomes very strong when the rate of change from development is considered. Suggestions were made during conduct of the survey that continuous documentation of system design effort be maintained to the extent feasible.

D. Review of Present Systems Documentation

During the course of the survey, documentation of present systems design status and activities became available from time to time. Additional material will doubtless appear, particularly on accomplishments at the University of Dayton. A more detailed level of documentation would have been quite helpful, especially with respect to "false starts" and changes in planning together with reasons therefor. Material reviewed for this survey includes those documents listed in the Bibliography. Existing documentation was, in most cases, inadequate for purposes of this study. In addition, it did not reveal whether gaps observed were those of documentation or those of attainment. The material available was useful as far as it went, but a systematic, planned series of informational products on the centers is needed.

E. Field Audit

The most significant input to this study appears to have been from field audit trips by key personnel assigned to the project. In no other way could an insight be gained to the validity of planning as related to the present and obvious facts of accomplishment. Exchange visits by managers of materials information centers could be a stimulating influence, and closer contact with the centers by their sponsors would be desirable. Organizations visited by C-E-I-R were:

1. Syracuse University Research Institute
2. Belfour Engineering Company
3. Armed Services Technical Information Agency (ASTIA)
4. University of Dayton
5. Aeronautical Systems Division (WPAFB, Ohio)
6. Hughes Aircraft Company
7. Thermophysical Properties Research Center (Purdue University)
8. Aerospace Industries Association

Additional personal contacts were made at the ASD Symposium on Materials Information Retrieval (28-29 November 1962) and at the ASD meeting of 30-31 January 1963 on materials information centers. Discussions and observations, especially at the centers themselves, provided a realistic basis for evaluation. All of the various questions developed for the survey could be covered to the extent applicable, and additional factors of special interest were uncovered. Actual results of the survey are discussed in the following section.

III. RESULTS OF THE SURVEY

A. Perspective

Two basic and closely related kinds of results emerged from the survey. First, an appraisal of individual centers was made. Comprehensive summaries of findings on each center studied appear in the Appendix to this report. A further brief set of comparative tables covering selected features of the centers is included at the end of this section. The second kind of result was a composite picture of what might be termed the materials information program. Even though this composite picture is as yet incomplete, some of its important aspects are discussed in the following paragraphs. These aspects provide a necessary frame of reference for conclusions and recommendations about the over-all materials information program as well as about the individual centers.

B. Acquisition of Materials Information

The origin, recognition, and reporting of relevant materials information are widely scattered, highly diverse activities lacking unified direction of technical and managerial aspects. Such conditions are inevitable for the foreseeable future. Much of this information is developed on defense dollars, either as specific materials studies or as necessary work relating to more general development and production contracts. Surveillance and acquisition assurance techniques differ for each of the centers under study. They range from passive acceptance of material selected by the sponsor (which actively acquires pertinent information) to diligent pursuit of world literature (including following of important individual contributors). Further differences among the centers exist (and rightly so in some situations) with regard to the following:

1. source identification
2. materials of interest
3. document acquisition capability
4. treatment of classified information
5. awareness of foreign developments
6. selection of primary (original) versus secondary information.

Although many of these differences between centers may be expected to continue, recommendations will be made later with the objective of reducing or eliminating some.

C. Analysis, Indexing, and Conditioning

Universal agreement exists among the four centers surveyed on the following general statements:

1. Technical review and analysis of incoming material must be done at the individual center receiving the material.
2. Indexing of information is the most important and costly single function at each center.
3. Consistency of indexing has been lacking except where classification schemes and terminology control are applied (and difficulties are encountered even then).

Operating methods, however, vary widely within each of the three areas listed above. Some of the differences arise from the fact that document retrieval is unlike data retrieval. Others stem from the unique objectives and specific technical orientation of the individual centers. Examples of areas of differences found are:

1. extent of situational identification necessary before acceptance of input.
2. willingness to accept "reduced" data rather than observed values.
3. degree of subject-matter specialization of indexing personnel.
4. relative use of duplicative work assignments to test consistency of coding determinations.
5. amount of extract or abstract preparation.
6. extent of data conversion and derivation of desired values.
7. number of indexing personnel covering the same source for different subjects.
8. verification of bibliographic references screened as possible input.
9. maintenance of references the content of which is mutually duplicative.
10. extent of use and kind of classification system.
11. content of terminology authority list (if used).

Because of difficulties encountered and the variety of approaches used, either there is no "best" single approach to indexing or else the right approach has not been identified.

D. Storage

File organization and storage media have posed no major problems up to this point in time. All of the centers could undergo physical relocation and resume operations so far as records per se are concerned. The major problems which would be encountered if such a move were made, considering only the use of the physical store of information, are:

1. lack of documented operating procedures necessary to use the store(s).
2. difficulty in devising a single set of procedures for operating with more than one center's store at a time.
3. inability of a host organization to maintain and update the store of information.

Interesting possibilities arose concerning use of analytical computer routines to evaluate statistically the content of stores of information which are now mechanized. Fundamental measures of accomplishments and costs might be developed and tested through a study of this type. Comparisons and correlations might also reveal better bases for organization of data files.

E. Interrogation and Retrieval

Too little information is available on interrogration and retrieval activities for adequate evaluation. From the sporadic efforts made to date in this area, summary observations can be made as follows:

1. specialists at the centers appear to be required as communication channels between users and the systems.
2. searches often require reformulation after review of intermediate or "final" results.
3. no study has been made to date toward increasing search efficiency (e.g., multiple inquiry processing; minimum access paths).
4. "test case" search problems have not been used to verify search capability in known areas.

This situation results from a lack of working relationships with users of materials information, as well as the relatively early stage of development of most of the centers. Because of the lack of concrete findings in this area, a recommended program of user development will be suggested later in this report. Further study of users will be required, as they are noticeably lacking during the conduct of the survey.

F. Machine Operations

All of the centers use mechanization at some stage of data processing. The size or quantity of automatic equipment used appears to have no relation to the size or effectiveness of operation. In certain instances dependence on mechanization is related to the type of system. For instance, raw data retrieval systems would be considerably weakened without a plotting facility to exhibit certain characteristics of numeric information. On the other hand, document retrieval systems can, in cases, operate quite well with little or no mechanization.

The over-all needs for automatic data processing equipment are flexible. It is noted however, that each of the centers served is prepared for immediate or future mechanization. The relative degree and needs of such will evolve with user demands.

SUMMARY COMPARISON CHARTS

SCOPE

	SUBJECT MATTER COVERAGE			INFORMATION SOURCES						TYPES OF INFORMATION			
INFORMATION CENTER	MATERIAL COVERAGE (ACTUAL)	PROPERTIES	GENERALIZED INFORMATION	ABSTRACTS	GOVERNMENT REPORTS	INDUSTRIAL REPORTS	UNPUBLISHED DATA	GENERAL LITERATURE	OTHERS	GRAPHIC AND PICTORIAL	COMPLETE DOCUMENTS	NUMERICAL DATA	EXTRACTS AND/OR ABSTRACTS
TPRC	All matter	Thermophysical (13 to date; 36 additional planned)	Theory; experimental techniques; observations	14 major abstracting services	ASTIA; OTS; AEC; Army; Navy; ASC; NASA; Library of Congress	Sponsors; also included in abstracts and Gov. reports	As available ①	As included under abstracts	University laboratory experimental personal contacts (USA and Europe)	Yes (graphic only)	No	Yes	Yes
MATERIALS CENTRAL — UD	Aerospace materials	Open - not subject to classification at this time	All related text which is significant	As covering in ASD-provided reports. Some written at U.D.	Studies sponsored & selections made by materials control	As included under abstracts	As included under abstracts	As included under abstracts	As included under abstracts	Yes	Yes	No	Yes
BELFOUR	Metals and plastics for aerospace industry	Mechanical and associated variables	Description of: materials; compositions; formulations; geometry; test procedures ②	Primarily ASTIA Tally also: NASA; DOD; Bureau of Standards; Business Conferences daily	ASTIA plus ASD selections	As available from aerospace industry	Limited use of new test data	Some ③	Uses ④	Yes	No	Yes	Yes
HUGHES	Semiconductors and insulators	Electric and electronic	All related text which is significant	8 major abstracting services	Primarily from ASTIA	Primarily from ASTIA	As available	Digest of literature of dielectrics; engineering index; over 367 periodicals used to-date	None	Yes	Yes	Yes	No

① Includes masters and doctoral dissertations from 183 universities and colleges.
② Also, heat treatments, mfg. processes, finishing processes, test procedures, behavior and failure coordinates, failure description.
③ Not specified.
④ Direct communication with users provides sources of information for improving the file when necessary.

ORGANIZATIONAL ASPECTS

INFORMATION CENTER	SPONSORSHIP AND SUPPORT	TYPE OF ENTERPRISE	STAFF (MAN YEARS/YEAR) PROFESSIONAL MAN-YEARS	GENERAL CLERICAL	FILE PROCESSING TECHNICIANS	TECHNICAL SPECIALTIES COVERED	EQUIPMENT	ESTIMATED EXPENDITURES/YR. (EX. OVERHEAD) SALARIES	MATERIALS	EQUIPMENT	SERVICES DOCUMENTS	OTHERS
TPRC	Industrial; ASD, ONR; NSF (1)	Educational	18	4	5	Chemistry; physics; thermodynamics; chemical engr; mechanical engr; metallurgy	IBM 1401; IBM 7090 (1964); Photo list; peripheral equipment (2)	(3)	(3)	$16,000	(3)	(4)
MATERIALS CENTRAL — UD	ASD	Government -- Educational	7	4	2	Chemistry; physics; metallurgy; chemical eng.	NCR 304; peripheral equipment (2)	$75,400	$3,550	$11,100	$10,000	$2,400 (4)
BELFOUR	ASD; limited additional clientele for fatigue data, medical data, and other services	Industrial	6	3	4	Metallurgy; statistics; data processing; mechanical engr; meteorology	Document writer; 602 calculator; X-Y plotter (logarithmic); statistical machine; peripheral equipment (2)	$80,000	$4,500	$10,000	$2,000	$5,000 (4)
HUGHES	ASD	Industrial	5	5	None	Physics; chemistry; crystallography; materials eng.	IBM 1401; peripheral equipment (2)	$72,000	$20,000	Included under materials	None	None

(1) 35 sponsors throughout the world.
(2) Key punch, reproducers, tabulators, etc.
(3) Estimated $220,000 for these four items (no further breakdown available).
(4) Print and reproduce, dissemination, etc.

PRODUCTS AND SERVICES

INFORMATION CENTER	PUBLICATIONS	TRANSLATIONS	RETRIEVAL OUTPUT	ANSWERS TO TECHNICAL INQUIRIES	INDEXED DOCUMENTS DISTRIBUTION	TECHNICAL CONSULTATION	SEARCH TOOLS (FOR USERS)	PUBLICITY
TPRC	Retrieval guide; TPRC data books; master thesis listing; technical reports	French; German; Dutch; Italian; Japanese; Russian; Spanish; and others	Bibliographical reference	Yes - If not provided by existing printouts	None	Yes ①	Retrieval guide; data books; index	Articles; speeches
MATERIALS CENTRAL / UD	None	None ②	Bibliographical references from UD; Content extracts by materials central	Yes	None ③	None ③	Dual dictionary	ASD-sponsored symposia, speeches, and informal contacts
BELFOUR	ASD TN-61-117 mechanical properties (Bi-monthly)	None	Data-Point plots (tabular data) lists of pertinent references; computed and derived (analyzed) information	Yes - equivalent to basic materials investigation	None	Yes - including In-Plant service with tape copy of file	Conversation as search progresses	Articles; speeches
HUGHES	Thesaurus; data sheets; state of the art reports; glossaries	French; German; Italian; Japanese; Spanish	Bibliographical Reference	Yes	None	Yes	Index - copies in company and ASD; tab runs of materials	Articles; speeches

① Free to sponsors, fee-basis to others.
②③ Some by translating agencies.
③ Provided internally by ASD.

OPERATIONS AND STATUS

INFORMATION CENTER	INDEXING	SEARCH INFORMATION (MINIMUM)	CONTENTS SELECTION	FILE ARRANGEMENTS	PROGRESS AND PERFORMANCE LEVELS
TPRC	Terms plus classification system	Material; Property	Only original data with major critical review and correlation effects	Classification developed by TPRC	System is operational. Book 2 completed of the retrieval guide. Work progressing on book 3. Data have been used and are well accepted.
MATERIALS CENTRAL / UD	Concept coordination using "Roles"; "Links" and deep indexing	Material; Property; Application	Passive (ASD responsibility)	Inverted file with "Roles" and "Links". 13 Roles incorporated	System design partially completed. Not fully operational. Consistency and effectiveness for retrieval not yet tested.
BELFOUR	Classification system derived from elements encountered during input analysis. "Open", "evolving" and subject to re-sequencing.	Initial search based on user contacts plus modification based on yield of pass.	To-Date: "High Yield" documents given priority to build basic file.	Duplicate card files by material and property with convenient subordinate breakdowns.	System is operational but undergoing modification. Additional data being extracted and encoded. Design of formats are complete
HUGHES	Terms (coordinate) plus classification system for data sheets	Material; property	Item must have experimental data on the electrical and electronic properties of materials	Pre-coordinated descriptors in Alpha sequence	System fully designed. Input processed (indexed and coded). Tables completed in many areas. Ready for actual inquiries.

GENERAL INFORMATION

INFORMATION CENTER	MATERIAL COVERAGE	PROPERTIES	INFORMATION SOURCES	TYPES OF INFORMATION	SPONSORSHIP AND SUPPORT	TYPE OF ENTERPRISE	TECHNICAL SPECIALTIES	PUBLICATIONS	RETRIEVAL OUTPUT	INDEXED DOCUMENT DISTRIBUTION	ANSWERS TO TECHNICAL INQUIRIES
BOEING	Plastics; elastomers; ceramics	Industrial chemical and surface; structural; mechanicals; thermal; electro-magnetic	MIL-HDBK-5 (handbook)	Numerical data; graphic & pictorial	ASD contract no. AF 33-(616)-8036	Industrial	Engineering services	None	Curve plotting; computed and derived (analyzed) information	None	Limited (some to parent company)
ASTIA	All fields of research and engineering undertaken by DOD	As covered in reports generated or sponsored by DOD	Documents and reports; government and through government contractors	Documents; abstracts and/or extracts	Department of Defense	Scientific Information center of DOD. Activity of Air Force systems command	Providing timely bibliographic service to gov't activities and gov't contractors	Thesaurus of ASTIA descriptors; ASTIA chemical thesaurus; technical abstract bulletin; cumulative indexes; KWIC indexes	Abstracts, bibliographic references	Copies of reports (subject to restrictions)	Yes - automated search and retrieval; telephone service
LIBRARY OF CONGRESS	Science & engineering technology, military science, naval science, materials of engineering and industry, testing	As covered in collected documents and reports	National and foreign International exchange of information; abstracts; gov't. reports; industrial reports; unpublished data; general literature	Documents; abstracts and/or extracts	U.S. Government	U.S. Government National Congressional Library	Science and technology; aerospace information; air research	Subject headings; catalog cards; information bulletin Quarterly journal of current acquisitions	Bibliographic references	None	Bibliographic services to Congress, gov't, industry, and gen'l public. Nat'l science and technology referral cntr. Opened to public 3/4/63 for scientific queries
SYRACUSE	Non-metallic structural	Physical; chemical mechanical; and manufacturing characteristics	Abstracts gov't. reports; indus. reports; unpublished data; general literature; personal contacts	Graphic and pictorial; numerical data	ASD Contract No. AF18(600)-1876; ASD contract No. AF 33(657)-8780	University owned research institute (non-profit)	Chemistry chemical engineering physics	Plastics handbook (Feb. or Mar. 1963)	Assembly of handbook sections and topics	None	None

IV. CONCLUSIONS

Following are a number of comments summarizing the findings of the survey. The findings are categorized under effectiveness, duplication, dissemination, mechanization, usage, acquisition, compatibility, and cost.

A. Effectiveness

1. Future organization of the Materials Information Program, whether centralized or decentralized, will depend on optimum grouping of these factors:

a. allocation of functions to an organizational component.

b. assembly of technical skills.

c. provision of information handling systems.

d. loading (unit volumes).

Some functions logically "go together"; others may be physically separated so long as reasonable coordination exists.

2. The objectives of any Materials Information Center are found generally to change, as time goes by, from those set forth at its inception. This change is natural. As the development process goes on, objectives will broaden. Operating systems will be influenced by eventual user demands. Remodeling, if necessary, will meet these demands.

3. The nature of the work done is such that specialists are needed more urgently to serve as communication channels between user and system at the Belfour facility than at any of the other units. At Belfour, a specialist depends on conversation with the user in determining search parameters. TPRC, on the other hand, requires little or no contact with the user. The "Retrieval Guide to Thermophysical Properties Research Literature" is adequate in most cases to supply bibliographic items pertinent to a user's interests. In cases where the current publication of the "Retrieval Guide" is not adequate, TPRC will supply information, on a fee-basis to non-sponsors, by telephone or mail. User requests are being received and answered by Materials Central-UD, but use should increase. The Hughes facility has experienced minor user requests. It is anticipated that both Hughes and Materials Central-UD will need additional specialist-user relations to effect adequate retrieval.

4. Information units must be strengthened if they are to keep up with the volume of recorded knowledge produced by advances in technology.

TPRC estimates that their level of effort in both the Scientific Documentation area and the Data Tables area must increase 40 to 50 percent to meet future demands. Hughes and Belfour will experience much the same increase. Materials Central-UD, because of insufficient man-power, is having difficulty processing the periodic supply of documents submitted to them from the Aeronautical Systems Division. Hence, the Materials Central-UD level of effort will have to increase still more.

These problems will continue. If the systems are to maintain currency, that is, if their outputs are not to be incomplete and/or much delayed in becoming available to the technical community, then expansion of ASD expenditures to meet these problems will be necessary.

5. Retrieval effectiveness of any indexing system can only be established on the basis of empirical research. There have been recent experiments (by Cleverdon and Swanson) directed at obtaining evidence for and against various indexing schemes. Neither of these experiments took into account the user of the information or made a judgment of the relevance of the information retrieved to specific problems. The effectiveness of an information system should be judged in terms of user requirements. A program to do so would be a step in the direction of comparing information systems in terms of their value to users, even though the criteria were crude. Such a study would probably be valuable.

6. Size and efficiency are complementary in many operations. But in materials information processing, functions become inefficient and complications arise if the information center becomes too broad. The operating nucleus should be sufficiently small to allow a high level of competence in the subject area. The competence, especially in technical specialties, would be difficult to maintain in a center with very broad subject coverage.

7. The function of retrieval in response to user inquiries has not been attempted on a scale adequate for evaluation of efficiency or cost.

8. The information storage and retrieval system maintained and developed by the University of Dayton in association with Materials Central is in an embryonic stage. Material being made available is limited both in quantity and as to source. The initial accomplishments have been in indexing the contents of documents, abstracting as necessary, key-punching the information and placing on magnetic tape. Types of questions to be answered by the center are unknown at this time. No study has been made, either at the University of Dayton or at Materials Central, to suggest user profiles or areas of user interests.

9. The application of links and roles to the information system of the University of Dayton has been limited. Presently, thirteen role definitions are being used. Lack of operating experience by the University of Dayton with links and roles makes impossible any specific evaluation. Moreover, within the Information Retrieval field, there is a dearth of information on comparative costs and effectiveness of the use of links and roles. Their use increases the input and processing costs; retrieval efficiency can be increased. Whether their usefulness warrants their cost has yet to be determined for the system. Mortimer Taube, in commenting on the use of links and roles in coordinate indexing, states that roles can eliminate noise (false drops) without loss of information and links may eliminate noise but only by eliminating useful information; he also states that it could be proved on theoretical grounds that the types of link systems which have been proposed in the literature of coordinate indexing are ineffective; that increased costs from their use may range from an estimated 5% to 50%. Roles will probably never eliminate noise completely. Also, it is purely conjectural that anybody can prove on valid ground (theoretical or not) that links are ineffective when used in coordinate indexing.

10. If Materials Central is to bring about improved performance, further compatibility, and increased cooperation among the centers, the sponsoring agency will require specialized technical staff personnel covering areas of interest represented.

B. Duplication

1. External duplication of effort between centers has been observed in one case (Hughes and TPRC). It is not necessarily harmful. From the user standpoint, specific information complemented by related information is often desirable, if not essential. For instance, in miniaturized or printed circuit design electrical properties as well as thermophysical properties of materials are needed. Hence, investigations of duplication should not be used to justify removing that duplication unless it is clear that this will not interfere with the service the user needs.

2. It is not known how much internal duplication of subject material occurs within any or each of the several systems under discussion. To determine this would require an examination of each file. Internal duplication, as the phrase is used here, means that the same documents or data are found in two places in the same system.

It is to be expected that some duplication of subject material will be present in each of the systems. TPRC and Hughes depend heavily on several abstracting journals; the same reference is often cited in more than one

abstracting journal. Belfour and Materials Central-UD are also likely to have this problem, although in somewhat lesser degree.

This type of duplication is more of a problem in "raw" data retrieval systems than in document retrieval systems. In a "raw" data system, duplication of subject material tends to result in placing too much confidence in the data which have inadvertently been duplicated. A related problem arises when better measurements are made of old phenomena. Advances in experimental techniques often result in revised or new values of long established parameters. When new values are inserted in a "raw" data system, if they are also "better" than the old ones, it is absolutely essential that older ones be removed. The result, if this is not done, is misleading or wrong information out.

The means presently employed by all of the centers to aid in solving this problem is periodic updating of the file and examination of lists and tabulations of file information.

3. The document library segment of the Materials Information Program located at University of Dayton contains mostly documents available through ASTIA. If the document library segment were shifted to ASTIA (an obvious step if economy in storage were the only factor) the following would need consideration:

a. some of the reports now processed would have to be placed in the ASTIA accessions program (i.e., those not now available through ASTIA).

b. the observed trend toward use of the ASTIA thesaurus should be verified.

c. usability of the ASTIA thesaurus terms for search without the use of links and roles (i.e., instead of the present UD system) should be tested by comparative searches with suitable adjustment for system content availability.

d. technical subject-matter indexing personnel might have to be added to the present ASTIA staff to carry the added indexing load.

e. a new liaison arrangement between ASD Materials Central and ASTIA would have to be developed.

C. Dissemination

1. The centers do not have the capability of distributing documents. Reproduction equipment is lacking. Methods of handling proprietary information, and possibly classified information with need-to-know, establishment of clearances, and verifications, have not been resolved.

2. The ability to produce a document (replica or relevant abstract) is an important aspect of a total system. The furnishing of documents is not as necessary in systems that store raw data (e.g., Belfour) as it is in systems whose output is a bibliography (e.g., TPRC).

3. The dissemination of information about the systems through publication is limited. There are no existing periodic means of informing users and potential users of the information center's potential or its capability. The publications of the centers, which are valuable, are data sheets, indices, tabulations, etc. The means generally employed for publicity are speeches, articles and personal visits.

D. Cooperation

Exchange of information among centers takes place at various symposia and through published articles. To date, there is no formal or semi-formal plan for direct exchange of information or cooperation between centers of similar interests.

E. Mechanization

Although rapid advances continue to be made in the speed of arithmetic operations in computers, computer manufacturers have not incorporated special devices that would aid materially in making searches. Considering the small volume of requests at the centers, so far, the use of large-scale computers for rapid searching would be costly and inefficient. If the volume of requests were to increase substantially, the use of computers might prove feasible. The essential but less complex functions of producing tabulations and listings can in many cases be implemented efficiently and economically by a computer.

F. Usage

1. Based on information available to date, TPRC has the greatest number of users. The "Retrieval Guide" is a convenient and simple way of obtaining bibliographic citations on a specific material and property. Direct queries to TPRC have been limited. The Belfour facility has a clientelle, but

the user must sacrifice time to obtain information. In fact, certain questions require a number of passes through the system to obtain acceptable output. Hughes and Materials Central-UD have experienced limited user requests. The fact that the great majority of TPRC users are not accessible for interview to this study makes a judgment on user-effectiveness difficult. In addition, since output from the "Retrieval Guide" is a bibliography, it would be even more difficult to estimate the number of users who went through the additional trouble to obtain the documents. A survey of information users in the Aerospace industries would be required to answer this question with any real confidence. Belfour, on the other hand, has direct contact with all users that request information from the center.

2. The creation of well-devised information retrieval centers, specialized or otherwise, does not automatically bring about customer usage. The climate of intellectual endeavor prevailing in science and technology is such that workers will tend to avoid information sources that are either time-consuming, costly, or troublesome to use. Potential users will be inclined to do without information or to duplicate work unless it is specifically required that diligent pursuit of information be practiced.

G. Acquisition

1. The acquisition program at Hughes, Belfour, and Materials Central-UD is determined primarily by documents made available from ASTIA and/or ASD. Documents supplied by ASTIA and ASD are mainly technical reports generated as a result of contracts of the Federal Government with outside domestic, educational, or industrial sources. Without an active acquisition program, both domestic and foreign (other than that conducted by Materials Central), centers are limited in their scope of subject matter coverage as well as limited in their usefulness to the Scientific and Technical community.

2. Of the total volume of published periodicals received by the centers, it was noted that only a relatively small percentage contained information pertinent to the Unit's subject coverage. TPRC estimates that 4% of the available literature produces 60% of the pertinent information. The publications in a center's collection should undergo periodic evaluation. The scanning of literature offering little or no contribution to the system is especially wasteful in a field like this where subject specialists are both needed and scarce.

3. The acquisition program takes different forms at different centers. Diligent pursuit of world literature, limited selection, and passive acceptance (certainly in the case of ASTIA) are all practiced. A total system acquisition program would attempt necessarily to include all available publications. Probably total coverage on any given subject will never be achieved. This is true not only because it would cost so much, but also because so much pertinent

information has either remained unpublished or been published with limited circulation and is hence inaccessible.

H. Compatibility

1. The extent of over-all compatibility (i.e., conformity to some common standard of indexing file structure, document coverage, etc.) among centers is, at this stage, difficult to evaluate. More specific compatibilities (e.g., file format, document coverage, indexing type, indexing language, etc.) exist in varying degrees. In general it can be said that no one system could, without very serious dislocation, be incorporated into or merged with another. All of the centers are in a development stage. User profiles are not defined. Indexing procedures differ substantially between raw data retrieval systems (e.g., Belfour) and document retrieval systems (e.g., Materials Central-UD). Acquisitioned data varies from that actively pursued in the world's literature to that available from limited domestic sources.

The information systems of the four centers, Belfour, TPRC, Hughes and Materials Central-UD, are not compatible nor have efforts been made to achieve compatibility among them. The Revised Index and Code Book (Belfour), the Retrieval Guide to Thermophysical Properties Research Literature (TPRC), the Glossary of Index Terms (Hughes), and the Dual Dictionary (Materials Central-UD) are not compatible. This also holds for a thesaurus in preparation by the University of Dayton. Here again, attention has not been directed toward compatibility of vocabularies, of glossaries, or of thesauri. Each center has its own authority list, its own methods of indexing, and its own methods of classification. Each center reflects its own method of collecting data and its own type of service.

There are many reasons for the differences among the centers. Only the main one need be stated: when the centers came into being, there was no "best" way of recording knowledge. The most one could do was survey the Information Retrieval field and attempt to make a judgment on what was applicable to his particular problem. This is still the case. Experimentation remains essential to a system design.

The gains which might be obtained by a program to achieve over-all compatibility of the centers' systems would not be sufficient to justify the cost.

2. Although the data processing functions among the centers are not compatible, it seems feasible that, with some effort, output of certain centers could be made available to the technical community in a similar or common way.

The output from the Belfour facility is numeric; output from Hughes, TPRC or Materials Central-UD is a bibliography. Hughes and TPRC deal with specific properties; Materials Central-UD does not. Of the four centers surveyed, TPRC and Hughes have the best potential, at least cost, of developing a common means of system output.

TPRC's "Retrieval Guide" is a convenient, timely, and economical way of obtaining bibliographic citations on a material and property. It seems practical that electrical and electronic properties of semiconductors and insulators might be embodied in similar publications.

I. Cost

The consideration of specific operational costs (e.g., indexing, storage, retrieval, etc.) of the four systems surveyed is, at this stage, secondary to the function of supplying information. The fact that functions at each center differ substantially from functions at other centers, as well as the fact that some (Materials Central-UD, Hughes) have serviced very few queries, makes it difficult to evaluate relative system costs. However, an over-all general allocation of funds for each system is listed in the Summary Comparison Charts.

V. RECOMMENDATIONS

After considering all observations emanating from surveillance of literature, field audit, and personal contacts, C-E-I-R, INC. presents the following recommendations relative to the Materials Information Program under sponsorship of Materials Central.

The recommendations represent a practical approach for Materials Central to pursue at this time, in view of the present state of Information Retrieval.

In addition to general recommendations, this section contains suggestions concerning effectiveness, usage, duplication, compatibility, and cooperation.

A. General Recommendations

In general, the recommendations are made that:

1. The Directorate of Materials and Processes of the Aeronautical Systems Division continue to support the establishment and maintenance of technical information research centers, charging them with responsibilities for accumulation, indexing, and synthesizing of data in designated highly specialized fields of materials.

2. Documents, indexes, files, cards, tapes, thesauri, handbooks, etc., be obtained as necessary from the technical information research centers or other sources in order to establish materials information dissemination service at Materials Central. Materials Central can make a major contribution by establishing a dissemination service. The individual centers should not, however, be discouraged or prevented from answering questions directly.

B. Effectiveness

1. It is recommended that Materials Central acquire technical information managers for each of the fields of interest represented.

2. The main criterion by which an Information Retrieval Center should be judged is how well it satisfies the user. The user must be known before an effective system design can be initiated. Unfortunately, the function of retrieval in the centers under study has not reached a level of activity adequate to allow even rough evaluation of its efficiency, cost, or efficacy. Retrieval must be tested if program effectiveness is to become known. It is recommended that in order to better evaluate the effectiveness of the system, the following be done:

a. ascertain what types of questions are most likely to arise, i.e., find out more about the user and

b. convert major portions of existing files at each center to machineable format and analyze the type of question that can be answered by machine processing. This will require exploration of the problem of suitability of each system for a computer system as well as forcing some evaluation of the degree of compatibility of each system with each of the others. This will also afford the opportunity to further investigate the question of duplication.

Since the records would carry information about input identities and characteristics, it is possible to use these files to establish a program for surveillance and acquisition of Materials Information. Much of this functional area could be conducted at Materials Central.

By manipulation of duplicate existing files, accurate comparative counts could be produced for several centers. Unit costs, entry gaps under classification schemes, and weighted distribution of file content would provide valuable factors for planning future acquisition programs. Analytical, statistical and comparative computer programs would be written to provide these and other significant management data.

Also, a usable file would be available for controlled, accelerated tests of retrieval capability. Waiting for the test of normal use will be slow, and areas of emphasis will (at first) be so fragmentary as to present a distorted profile of over-all future activity. Admittedly, tests should be developed based on user characteristics, but they need not be delayed because of user ignorance. Planned tests could expedite both use and capability increases. The Aerospace Industries Association has indicated interest in study of this type, and their cooperation might be secured for arranging accelerated representative use participation.

3. It is recommended that Materials Central investigate the completeness of the list of periodicals and documents reviewed by the various centers. Materials Central may want to increase the number of periodicals reviewed, especially foreign ones, and may also wish to consider which ones are the most vital. As pointed out in the conclusions, many times a small fraction of periodicals yields the majority of stored information in a system. It is also recommended that Materials Central make it possible for the centers to have the capability of reproducing documents. This will entail the procurement of appropriate reproducing machines. It will also necessitate solving problems of copyrights, classified information and need-to-know requirements.

4. It is recommended that management of a center have two special qualifications:

a. knowledge of Information Retrieval techniques and

b. a deep appreciation of the technical data being maintained.

Knowledge and dedication ought to be present in the management of the center.

5. It is recommended that little effort at this stage be given to writing computer programs to perform searches on the computer. The present and anticipated volume of requests does not warrant it. However, it is recommended that more use be made of computers to produce tabulations. In general, handbooks are a feasible and economical by-product from many Information Retrieval Centers.

The importance of affording the potential user the opportunity to browse through the data and information available in a system cannot be overemphasized.

6. It is recommended that Materials Central review all the properties being investigated with the possibility in mind that some vital areas of interest are being overlooked; for example, chemical properties. This can easily happen because of the rapidity of progress. What was unimportant yesterday may be vital today. In the same manner, what is just interesting today may be major tomorrow. With some discretion, one may be able to study information today in anticipation of its importance tomorrow. Continuity in Information Systems is worth trying for. It is always difficult to catch up with what has gone by.

7. It is recommended that Materials Central make arrangements with each center such that each will respond to requests from all Air Force contractors even though the particular contractor is a competitor to the parent company of the center.

8. As an aid to Materials Central in determining the status of the Information Retrieval programs, it is recommended that a questionnaire be used in place of the regular monthly report letters. Undirected progress reports generally brighten areas where work has been successful and shade or exclude areas where work has not progressed as planned. A questionnaire helps solve the problem of "what to say" for the contractor, and, with the proper format, can assist in answering some questions of special interest to the contracting agency. In addition, personal visits to the centers by a Materials Central Project Engineer would be helpful in determining progress on a contract.

9. It is recommended that when possible, information retrieval centers profit through the experience of established and operating centers such as ASTIA and other similar organizations. People in Information Retrieval reproach the technical community for not making much use of more than a fraction of the information present in the literature. Yet, it is felt that these same Information Retrieval people, when setting up an information system, do not take time to profit from the experiences other people have had in the field.

10. It is recommended that queries be allowed to come either to the technical center or to Materials Central. This would give Materials Central the opportunity to become familiar with user queries and would help to determine the extent of future involvement of Materials Central in the Materials Information Program.

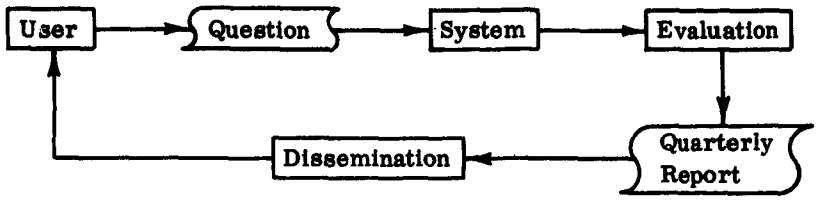
11. Materials Central ought to be host to periodic meetings among its contractors to discuss common problems like duplication, effectiveness, indexing, etc.

12. In order to give efficient service in a reasonable period of time, the Materials Information Centers must have competency in personnel. The subject area must not be so broad so that a researcher is unable to identify his area of specialization within the available information. That is, the subject area of a center should not be distant from a researcher's specialization. This necessity imposes a limit on the size of a center for effective operations. It is also unreasonable to expect any one center ever to have the capability to handle the properties covered by all the individual centers.

13. One of the basic problems in the Materials Information field is that user requirements are not known. A determination of system effectiveness is dependent on this knowledge. In addition, a knowledge of user requirements will aid in evaluating the present materials information program for completeness of subject coverage and the types of information systems that are desired by the technical community. The question of how much duplication of effort and compatibility among the centers there ought to be may be more easily resolved.

A program to determine user requirements is recommended as in the best interests of both Materials Central and the technical community as a whole.

Following is a general outline on how such a program may be carried out:



a. A specialist team assigned by Materials Central in cooperation with Materials Central contractors will determine what analysts ("analyst" will be used as the generic term for scientist, engineer, etc.) are potential users of the information store at each of the centers.

b. Once the analysts have been located, members of the team will visit each one, or a selected sample. During the visit, discussions will be held with them about projects they have worked on or projects they are working on. In this interview, they will be told of the availability of certain Materials Information Systems and asked to suggest typical problems they face in obtaining information concerning their analytic work. For each problem, they will be asked to compose search questions designed to solve them.

c. Each of the questions will be submitted to one or more of the information centers. At the center or centers, the questions will be translated into the search criteria appropriate for answering it.

An alternative to submitting the questions to the individual centers is to have the copies of the information files at a centralized location.

d. The responses to the retained questions submitted from the analysts will be evaluated by the specialist team in association with the analysts in the following way:

(1) copies of the output from the systems and documents (when applicable) will be given to the analyst.

(2) the analyst will examine the presented material.

(3) the analyst will judge the degree of relevance of the output relative to information already obtained from other means (if the project had already been completed) or relative to information desired (for a project already in progress).

(4) the analyst will also indicate, to the best of his knowledge, whether or not the information is complete, accurate and if it was made available in a reasonable amount of time.

e. Using the questions and output from the systems plus the evaluation of the analyst, periodic reports (say quarterly) will be issued to all Materials Central contractors and other interested parties. This report would give the present status of potential and capability of each of the centers as well as a "case history" account of queries and interpretations.

f. The program (initiated and monitored by Materials Central) will continue until a user profile has been developed and the systems are serving questions in volume.

14. The "Retrieval Guide to Research Literature" published by TPRC is an efficient, timely and economical way of obtaining bibliographic citations on a material and property. The output from the Retrieval Guide is the same that one would obtain if a question were addressed to TPRC directly. The methodology for the Retrieval Guide has already been devised by TPRC. Using this methodology or one like it, a similar publication concerning electrical and electronic properties of insulators and semiconductors is recommended. It is also recommended that an examination be made to determine if a handbook could be prepared as a by-product of the Belfour facility.

In effect, these publications make reference literature from the three centers (Hughes, Belfour, and TPRC) part of a user library. This, of course, would not eliminate completely the need for direct contacts to the respective centers when users would find it in their interest to do so, but it would provide a timely, efficient, economical and simple way to obtain improved access to literature and data that has not heretofore been sufficiently available.

15. It is recommended that an immediate study be undertaken with ASTIA (Science and Technology Division) to determine whether the document library portion of the materials information program can be handled successfully by ASTIA.

For literature outside the ASTIA accession program, the newly reorganized information center of the American Society for Metals should be studied as to its possible adequacy and suitability.

C. Usage

1. It is strongly recommended that a budget be allotted to publicize the Information Retrieval centers. What good is the most elaborate of systems

if it's never or seldom used? The Air Force should consider including in some of its contracts a statement requesting that the contractor make a state-of-the-art study. It should be possible to require that an Information Retrieval audit be made in a fashion somewhat similar to the concept of a government financial audit to check what the contractor did to make use of available information.

2. In order to inform the contractors of available information and data systems, a Materials Central newsletter is recommended publicizing the specific values of Information Centers and the services available.

D. Duplication

It is recommended that little effort at this time be expended towards reduction or elimination of duplication of effort among the information units. An examination of duplication, its advantages and disadvantages, would require a study of potential users as well as a study of system files. Although C-E-I-R did find duplication to some extent among the systems, it would be premature to evaluate its effects, harmful and/or helpful, without first determining user requirements.

E. Compatibility

It is recommended that at present no steps be taken to make the various systems more nearly compatible with one another. As discussed in the Conclusions, Information Retrieval in general has not developed to the extent where compatibility is necessarily an over-all requirement. Compatibility is such an intangible with regard to Information Retrieval that to require it in present systems would, in our opinion, tend to stifle progress, possibly increase cost and still not lead to systems tailored to the user's demands or requirements.

F. Cooperation

Rather than being concerned about duplication and compatibility, it is recommended that it will be most beneficial to push in the direction of much closer cooperation. The seminars that Materials Central has sponsored with the contractors have encouraged mutual assistance. Materials Central should continue to sponsor periodic seminars or colloquies with information retrieval contractors to encourage more cooperation.

In reality the centers are more integrated into the information retrieval community than would appear from superficial examination. Review of the same documents is a form of cooperation. Where similar interests exist

concerning documents, individual centers should either exchange documents or seek a common source such as ASTIA. In other words, the Information Retrieval centers ought to cooperate more especially in connection with the acquisition of documents. In particular, University of Dayton should only contain those documents that are not available from other agencies (e.g., ASTIA).

In summary, C-E-I-R recommends that Materials Central implement or encourage implementation of the following programs:

1. the establishment of a central Dissemination Service.

2. encouragement for use of Information Retrieval services.

3. initiation of closer monitoring function for the Information Centers.

4. investigation of user requirements.

5. encouragement of cooperation among the several centers and the Information Retrieval community.

6. exploration of the question of how far any existing center's work could be carried on by better use of ASTIA or similar organization.

VI. BIBLIOGRAPHY

A. This bibliography is a partial list of the literature used during the survey. Only those items that contributed to the compilation of this report have been cited.

1. Barden, W. A., William Hammond, and J. Heston Heald, "Automation of ASTIA," A Preliminary Report, 1 December 1959.

2. Barton, A. R., V. L. Schatz and L. N. Caplan, "Information Retrieval on a High Speed Computer," General Electric Company, Cincinnati, Ohio. Proceedings of the Western Joint Computers Conference, Vol. 15, 3-5 March 1959, San Francisco, Calif.

3. Belfour, A. J., "A Practical Approach to Providing Materials Information," Technical Information Systems Division, Belfour Engineering Company. Presented at Aeronautical Systems Division Symposium on Materials Information Retrieval, Dayton, Ohio, 28-29 November 1962.

4. Bourne, Charles P., "The Historical Development and Present State-of-the-Art of Mechanized Information Retrieval Systems," Stanford Research Institute, Menlo Park, Calif., Am. Document, April 1961, 12(2), pp. 108-110.

5. Braden, R. C., "Establishment of a Mechanical Property Information System," Progress Report No. 2, 18 December 1962, Technical Information Systems Division, Belfour Engineering Company, Contract No. AF 33(657)-9149.

6. Costello, J. C., Jr., "Storage and Retrieval of Chemical Research and Patent Information by Links and Roles in Du Pont," E. I. duPont de Nemours and Co., Wilmington, Del., Am. Document, April 1961, 12(2), pp. 111-120.

7. Crowley, William V., "Special-Purpose, Electronic Data Systems--The Solution to Industrial and Commercial Automation," Ramo-Wooldridge Corporation, Los Angeles, Calif. Proceedings of the Western Joint Computers Conference, Vol. 15, 3-5 March 1959, San Francisco, Calif., pp. 143-145.

8. Doyle, L., "Programmed Interpretation of Text as a Brief for Information-Retrieval Systems," System Development Corp., Santa Monica, Calif., Proceedings of the Western Joint Computers Conference, Vol. 15, 3-5 March 1959, San Francisco, Calif., pp. 60-63.

9. Fein, Louis, "The Role of the University in Computers, Data Processing, and Related Fields," Proceedings of the Western Joint Computers Conference, Vol. 15, 3-5 March 1959, San Francisco, Calif., pp. 119-126.

10. Gillum, T. L., and P. H. Klingbiel, ASTIA; C. N. Mooers, Zato Co.; E. Wall, Documentation, Incorporated, "The Philosophy and Guidelines for Revision of the Thesaurus of ASTIA Descriptors," 1 November 1961, Armed Services Technical Information Agency.

11. Grove, C. S., Jr., and R. Ford Pray, III, "Information Requirements for Application of Non-Metallic Structural Materials to Aerospace Vehicles," Syracuse University Research Institute, WADD TR 60-446, Contract No. AF 18(600)-1876.

12. Grove, C. S., Jr., and R. Ford Pray, III, "Materials Design Handbook for Aerospace Vehicles," pp. 1182-1184, SPE Journal, November 1961.

13. Hammond, William, "Evolution of the ASTIA Automated Search and Retrieval System," AD 252 000, January 1961.

14. Hammond, William, and Staffen Rosenborg, "Experimental Study of Convertibility Between Large Technical Vocabularies with Table of Indexing Equivalents" August 1962, Datatrol Corporation, Silver Spring, Maryland, Technical Report IR-1. Contract No. NSF C-259 of Office of Science Information Service, National Science Foundation.

15. Hayes, Robert Mayo, "The Interdisciplinary Character of Information Retrieval," UCLA Data Processing Center. Paper presented at U. S. Civil Service Commission Conference on Technical Libraries and ADP, 26-27 October 1961, Washington, D. C.

16. Holm, B. E., L. E. Rasmussen, "Development of a Technical Thesaurus," 1961, E. I. du Pont de Nemours and Co., Wilmington, Delaware, Am. Document, 12(3):184-190.

17. Johnson, H. Thayne, "An Information Retrieval Program on the Electrical and Electronic Properties of Materials," Hughes Aircraft Company.

18. Johnson, H. Thayne, Emil Schafer, and Everett M. Wallace, "Electrical and Electronics Properties of Materials, Information Retrieval Program," Hughes Aircraft Company, Technical Documentary Report No. ASD-TDR-62-539, June 1962, Contract No. AF 33(616)-8438.

19. Johnson, Loren F., and Howard W. Smith, "Engineering Services to Store Materials Information Data on Magnetic Memory Tapes," Boeing Company, Wichita, Kansas, Contract No. AF 33(616)-8036.

20. Jonker, Frederick, "Outline of General Method of Index Terminology and Indexing Methods," Jonkers Business Machines, Inc., Gaithersburg, Maryland, October 1961, AD 272 820.

21. Kellogg, Charles, "The Fact Compiler: A System for Extraction, Storage and Retrieval of Information," Ramo-Wooldridge, Canoga Park, Calif., Proceedings of the Western Joint Computer Conference, Vol. 17, 3-5 May 1960, San Francisco, Calif., pp. 73-82.

22. Kessel, B., Computer Control Company, and A. De Lucia, Rome Air Development Center, "A Specialized Library Index Search Computer," Proceedings of the Western Joint Computers Conference, Vol. 15, 3-5 March 1959, San Francisco, Calif., pp. 57-59.

23. Kessler, M. M., "Technical Information Flow Patterns," Massachusetts Institute of Technology, Proceedings of the Western Joint Computer Conference, 9-11 May 1961, Los Angeles, Calif., pp. 247-257.

24. Maron, M. E., J. L. Kuhns, and L. C. Ray, "Probalistic Indexing," Thompson, Ramo-Wooldridge, Inc., AD 272 572.

25. Miller, L., J. Minker, W. G. Reed, and W. E. Shindle, "A Multi-Level File Structure for Information Processing," Astro-Electronic Products Division, RCA. Proceedings of the Western Joint Computers Conference, Vol. 17, 3-5 May 1960, San Francisco, Calif., pp. 53-59.

26. Mooers, Calvin N., "The Next Twenty Years in Information Retrieval: Some Goals and Predictions," Zato Company, Cambridge, Mass. Proceedings of the Western Joint Computers Conference, Vol. 15, 3-5 March 1959, San Francisco, Calif., pp. 81-86.

27. Moore, Robert T., "A Screening Method for Large Information Retrieval Systems," National Bureau of Standards, Washington, D. C., Proceedings of the Western Joint Computers Conference, Vol. 19, 9-11 May 1961, Los Angeles, Calif., pp. 259-274.

28. Opler, A., and N. Baird, "Relative Merits of General and Special Purpose Computers for Information Retrieval," Computer Usage Co., New York, N. Y., Proceedings of the Western Joint Computers Conference, Vol. 15, 3-5 March 1959, San Francisco, Calif., pp. 54-56.

29. Salton, Gerard, "Some Experiments in the Generation of Word and Document Associations," Harvard University. American Federation of Information Processing Societies, Conference Proceedings, Vol. 22, 1962, Fall Joint Computer Conference, pp. 234-250.

30. Samson, Robert T., "The Role of USAF Research and Development in Information Retrieval and Machine Translation," Rome Air Development Center, Griffiss AFB, New York. Proceedings of the Western Joint Computers Conference, Vol. 15, 3-5 March 1959, San Francisco, Calif., pp. 66-69.

31. Schultz, Claire K., and Clayton A. Shepherd, "A Computer Analysis of the Merck Sharp and Dohme Research Laboratories Indexing System," 10 October 1960. Remington Rand UNIVAC. Am. Document, April 1961, 12(2), pp. 83-92.

32. Schriever, B. A., "Materials Center," Aviation Daily, Vol. 136, No. 9, 14 September 1961, p. 76.

33. Semarne, H.M., "Symbolic Logic in Language Engineering," Douglas Aircraft Company, Inc. Proceedings of the Western Joint Computers Conference, Vol. 17, 3-5 May 1960, San Francisco, Calif., pp. 61-71.

34. Swanson, Don R., "Information Retrieval; State of the Art," Ramo-Wooldridge. Proceedings of the Western Joint Computers Conference, Vol. 19, 9-11 May 1961, Los Angeles, Calif., pp. 239-246.

35. Taube, Mortimer, "Notes on the Use of Roles and Links in Coordinate Indexing," Documentation, Incorporated, Am. Document, April 1961, 12(2), pp. 98-100.

36. Taube, Mortimer, Josephine J. Jaster, and Barbara R. Murray, "The State of the Art of Coordinate Indexing," February 1962, (Preliminary Edition), Documentation, Incorporated. Prepared for Office of Science Information Service, National Science Foundation under Contract No. NSF-C-147.

37. Touloukian, Y. S., "The Thermophysical Properties Research Center, An Effective Answer to Information Needs on Thermophysical Properties of Matter," Thermophysical Properties Research Center, Purdue University, Lafayette, Indiana. Symposium on Materials Information Retrieval, Dayton Biltmore Hotel, Dayton, Ohio, 28-29 November 1962.

38. Touloukian, Y. S., C. H. Stevens, R. H. Rodine, T. Wing, D. W. Smith, "Systems and Procedures Developed for the Search, Coding and Mechanized Processing of Bibliographic Information on Thermophysical Properties," Thermophysical Properties Research Center, Purdue University, Lafayette, Indiana. Thermodynamic and Transport Properties of Gases, Liquids, and Solids, pp. 71-91, ASME Symposium on Thermal Properties, Purdue University, 23-26 February, McGraw-Hill, N. Y., TPRC Publication 5, February 1959.

39. "Air Weapons Materials Applications Handbook, Metals and Alloys," First Edition, December 1959, ARDC TR 59-66.

40. "Automation of ASTIA-1960," December 1960.

41. ASTIA Chemical Thesaurus, December 1962.

42. "Composite Construction for Flight Vehicles, Fabrication, Inspection, Durability and Repair," MIL-HDBK-23, Part I, 5 October 1959.

43. "Composite Construction for Flight Vehicles, Design Procedures," MIL-HDBK-23, Part III, 9 November 1961.

44. "Controlling Literature by Automation," ASTIA. Presented at the IV Annual Military Librarians' Workshop. October 1960. Reprint September 1962.

45. "Description of Systems Being Developed at WPAFB," write-up received from Aeronautical Systems Division, Wright-Patterson AFB, Ohio.

46. "Documentation, Indexing, and Retrieval of Scientific Information," United States Senate, 86th Congress, 2nd Session, Report of the Committee on Government Operations. Document No. 113, 23 June 1960.

47. "Documentation, Indexing, and Retrieval of Scientific Information," United States Senate, 87th Congress, 1st Session, Report of the Committee on Government Operations. Document No. 113, 10 March 1961.

48. "Final Report on First Revision of the Thesaurus of ASTIA Descriptors," 6 August 1962, AD 278 168.

49. "Guidelines for Using ASTIA Descriptors," February 1961, Armed Services Technical Information Agency.

50. "Information Retrieval Program Electronic/Electrical Properties of Materials," First Quarterly Progress Report, 10 October 1961, Hughes Aircraft Company, HAC Document Number 5171.2/8.

51. "Information Retrieval Program Electronic/Electrical Properties of Materials," Third Quarterly Progress Report, 15 April 1962, Hughes Aircraft Company, HAC Document Number 5171.2/32. Second Quarterly Report.

52. Key Words in Context (KWIC), Title Index of ASTIA Reprints - Not Previously Announced, No. 1, October 1962 (Initial Issue).

53. "National Referral Center for Science, Technology Cites Aims," pp. 4-5 ARMY Research and Development, Vol. 4, No. 2, February 1963, Monthly Newsmagazine of the Office of the Chief, Research and Development, Headquarters, Department of the Army.

54. "The National Union Catalog - Increase in Subscription Price," American Library Association, Committee of Resources, letter undated.

55. "Nonconventional Technical Information Systems in Current Use," No. 3, October 1962, National Science Foundation, NSF-62-34.

56. "Plastics for Flight Vehicles, Reinforced Plastics," MIL-HDBK-17, Part I, 5 November 1959.

57. "Plastics for Flight Vehicles, Transparent Glazing Materials," MIL-HDBK-17, Part II, 14 August 1961.

58. "Price Announcement on 1963 Subscriptions to the Various Library of Congress Catalogs," Library of Congress, letter undated.

59. "Strength of Metal Aircraft Elements," MIL-HDBK-5, March 1961.

60. "Tape Storage of MIL-HDBK-5," Boeing Company.

61. Thesaurus of ASTIA Descriptors, Second Edition, December 1962.

62. Visit to Belfour Engineering Company, Suttons Bay, Michigan, 19 October 1962.

63. Visit to Hughes Aircraft Company, Culver City, California, 28-29 February 1963.

64. Visit to Information Processing Section, Applications Laboratory, Directorate of Materials and Processes, Aeronautical Systems Division, Wright-Patterson AFB, Ohio, 12-13 December 1962.

65. Visit to Syracuse University Research Institute, Syracuse, New York, 18 October 1962.

66. Visit to Thermophysical Properties Research Center, Purdue University, Lafayette, Indiana, 16 January 1963.

67. Visit to University of Dayton Research Institute, Dayton, Ohio, 14 December 1962.

APPENDIX I

BELFOUR ENGINEERING COMPANY

Through sponsorship from ASD, Directorate of Materials and Processes, Applications Laboratory, Wright-Patterson AFB, Ohio, contract no. AF 33(657)-9149, the Belfour Engineering Company collects, stores and retrieves data on mechanical properties of metals and plastics and variables affecting these properties.

The primary purpose of this center is to provide personnel in defense industries, and particularly the aerospace industries, with relatively direct answers to their questions concerning material properties. These include metals fatigue test data, tensile strength, compression, and flexure and creep of reinforced plastics and metals.

The Belfour facility includes both a Technical Information Center and a Data Systems Center. They have studied the medical data storage and retrieval problem among others. The system was established in 1957 and has developed capability of answering inquiries in depth. As a matter of design, the information being processed, stored, retrieved and presented is dictated largely by the type of questions asked by design and production engineers, who have the ability to use curves and tabulated data effectively.

Acquisition

The primary sources of information are both published and unpublished reports of actual materials investigations.

The program for obtaining information includes documents made available through ASTIA, NASA, DOD, and Bureau of Standards. The unpublished data compilation program sponsored by Aeronautical Systems Division, Wright-Patterson AFB, Ohio, yields a large volume of pertinent and useful properties data. Also, direct communication with users provides sources of information for improving the file where necessary.

The basic units of information are experimental results, testing procedures, preparation of specimens and other pertinent descriptive information. Recent processing of input documents containing high data concentrations indicates that an input rate of 100,000 to 500,000 (their goal for the next 12 month period) data points a year can be maintained. A data point is a single value for a given property relating to all significant conditions concerning its origin.

Documents are indexed and are machine-retrievable for preparation of supplemental reference lists.

A current accounting indicates that approximately 3500 documents containing test data of metals and plastics have been accumulated. Of these, about 400 were received from organizations compiling unpublished data under the Air Force program.

System

The individual test results and descriptive information for metals and reinforced plastics are extracted manually from information sources, along with approximately 70 categories of qualitative and quantitative modifiers, each of which adds additional meaning to the particular property. The separate categories of descriptive information are called Information Units. Test coordinates and descriptors of all associated information units (data point) are stored. Each data point is tagged with the identification of the reference from which it was extracted. Following are some of the major headings under which modifying information falls for metal alloys (slightly different for plastics):

1. Reference Identification
2. Material Identification
3. Material Composition
4. Surface Conditions and Treatment
5. Melt Practice
6. Heat Treatment Procedures
7. Processing Procedures
8. Specimen Geometry and Dimensions
9. Pre-test Conditions
10. Test Equipment
11. Test Level Rates
12. Intermediate Coordinates
13. Failure Coordinates
14. Failure Description

These major categories are further divided to provide for and store most of the items which are either identified, controlled, or varied during mechanical properties determinations. Coding of categories is being revised as experience is gained through inquiry and search.

A three-card format, Tensile Tests Standard, Metals, is used for the storage of standard tensile properties of metals and associated information. Card A, Figure 1, is for the results and descriptive information associated with a single specimen of a test set. Card A_n, Figure 2, is for encoding additional test information including pre-failure measurements. Card B, Figure 3, is for

describing the composition, fabrication, and metallurgical properties common to a unit of material. An Encoder's card is available for the encoder to write comments and to reference document pages. A format of descriptive information on mechanical properties of metals is outlined in Figure 4.

There are two files in the system, a Detail Data File and a Summary Data File. The Detail Data File is a list of all the data points stored under a large variety of subject headings and subject interactions. In order to manage the information in the system, this file is constantly analyzed and updated. The Summary Data File includes the references that discuss or summarize any of the mechanical properties of material without reporting actual test results. This file includes handbooks such as the Syracuse University's Air Weapons Materials Handbook, DMIC Reports, etc. It has two purposes: (a) acts as a guide to future data input in cases when searches result in answers in the Summary Data File with no corresponding test data in the Detail File; (b) it satisfies a portion of the requirements for indication of errors by redundancy that has been designed into the information processing system.

Retrieval

Each request is reviewed to be sure sufficient information is provided and a similar search has not already been done. All searches are recorded. When asking a question of the system, any combination of requirements can be placed on the data. After each pass through the system, the requirements may be broadened or tightened, depending upon the yield of the pass. By taking full advantage of yield on each pass, it is possible to obtain the effects of additional variables covered in source documents.

The division by major categories and the breakdown under each category permits, through proper identification and definition, answers to almost any of the subjects that engineers usually associate with mechanical properties of materials. If the question is not answered specifically, then the next closest information in the file that may be of value is presented. Also, any other conditions which may affect that property are presented even though these were not specifically requested.

Typical output is a plot of all data points in the file concerning a given property under desired test conditions and generally a supplemental reference list is provided if data is limited. Points plotted are identified by source or other criteria to permit user evaluation and adjustment. If it is desired to work with the references themselves, rather than the system's data presentations, a list will be provided that satisfies the requirements.

At present, answers to questions have been provided to various organizations in the United States, Canada and other NATO countries. Service is provided,

without charge, through the sponsorship of ASD, Directorate of Materials and Processes.

A large portion of the data store is recorded on magnetic tape to permit a staff member to perform services at remote installations. Tape-to-card conversion from the magnetic tape master file can be accomplished at the user's facility, followed by processing on a conventional sorter. Extraction rate is something better than .05 manhours per point. Based upon approximately 100 searches, indications are that the cost of retrieving this information is a maximum of $.25 per data point. Typical searches yielding between 1000 and 500 data points demonstrate retrieval costs ranging from 0.1 to 1.0 cents per point.

Dissemination

Revised index and code book (December 1962).

Machine Operations

1. Document writer
2. Reproducer
3. Keypunches
4. X-Y Plotters (Logarithmic)
5. 602 Calculator
6. Statistical Machine (with provision for plugboard modification by pushbutton matrix, designed and constructed by Belfour Engineering Company)

Field Number		Number of Columns
1.0	**Bibliographic Identification**	
1.1	Reference	3
1.2	Test Type	2
1.3	Material Identification (Material Type)	4
1.4	Material Type	1
1.5	Unit Number	2
1.6	Set Number	2
1.7	Number of Specimens in Set	2
1.8	Specimen Number	2
2.0	**Material Fabrication**	
2.1	Melting Practice	1
2.2	Primary Operation	1
2.3	Secondary Operation	2
2.4	Heat Treatment (Material Type)	2
2.5	Surface Treatments and Finishes	2
2.6	Surface Finish	2
2.7	Specimen Configuration (Test Type)	2
2.8	Specimen Thickness or Diameter Times 10	2
2.9	Specimen Fabrication Procedure (Test Type)	2
2.10	Notch Configuration	2
2.11	Notch Factor	2
3.0	**Pre-Test Conditioning Field**	
3.1	Pre-test Conditions or Operations and Units	2
3.2	Pre-test Conditioning or Operations Amount	3
3.3	Time at Pre-test Conditioning Hrs/100	3
4.0	**Material Hardness**	
4.1	Type of Hardness Measurement	1
4.2	Hardness	2

Figure 1. Tensile Test Standard, Metals, Card A

Field Number		Number of Columns
5.0	**Test Condition**	
5.1	Orientation of Fibers, Grains, Crystals, to Load	2
5.2	Test Rate Units of Measurement	1
5.3	Test Rate	3
5.4	Test Environment and Units	2
5.5	Test Environment Amount	3
6.0	**Test Results**	
6.1	Ultimate Tensile Stress, ksi	3
6.2	Yield or Proportional Limit, ksi	3
6.3	Percent Offset (Test Type)	1
6.4	Gage Length Inches (Test Type)	1
6.5	Percent Elongation at Failure or End of Test	2
6.6	Percent Reduction in Area at Failure or End of Test	2
6.7	Initial Tangent Modulus of Elasticity, psi/10^5	3
6.8	Poisson's Ratio	2
6.9	Failure Description (Test Type)	1
7.0	**Card Sequence & Indicator Field**	2

Figure 1 (Cont'd)

Field Number		Number of Columns
1.0	**Bibliographic Identification**	
1.1	Reference	3
1.2	Test Type	2
1.3	Unit Number	2
1.4	Set Number	2
1.5	Specimen Number	2
2.0	**Test Results**	
2.1	Yield Strength or Proportional Limit, ksi	3
2.2	% Offset (Test Type)	2
2.3	Yield Strength or Proportional Limit, ksi	3
2.4	% Offset (Test Type)	2
2.5	Type of Modulus of Elasticity (Test Type)	1
2.6	Modulus of Elasticity Divided by 10^5	3
2.7	Stress or Strain at Modulus of Elasticity Measurement ksi or micro inches/inches divided by 100	3
2.8	Type of Load and Deformation Measurement (Test Type)	1
2.9	Deformation Instrumentation (Test Type)	1
2.10	Stress-Strain (Load - Deformation)	41
2.11	Ultimate Tensile Strength, ksi	3
2.12	Ultimate Tensile Strength or Deformation	3
2.13	Card Sequence & Indicator Field	2

Figure 2. Tensile Tests Standard, Metals, Card A_n

Field Number		Number of Columns
1.0	**Bibliographic Information**	
	1.1 Reference Number	3
	1.2 Unit Number	2
	1.3 Material Identification (Material Type)	4
	1.4 Material Type	1
	1.5 Material Form	1
2.0	**Material Composition**	39
3.0	**Material Fabrication**	
	3.1 Percentage Reduction - divided by 10	2
	3.2 Starting Temperature of Reduction °F/10	3
	3.3 Finishing Temperature of Reduction °F/10	3
4.0	**Metallurgical Properties**	
	4.1 Grain Size	2
	4.2 Inclusion Count (Material Type)	2
	4.3 Principal Constituent (Material Type)	2
	4.4 Percentage of Principal Constituent	2
	4.5 Other Constituents (Material Type)	2
	4.6 Percentage of Other Constituents	2
5.0	**Material Density**	2
6.0	**Other Types of Tests**	4
7.0	**Unassigned**	3

Figure 3. Tensile Test Standard, Metals, Card B

Document Identification

Author(s)
Source
Title
Accession Number
Date

Material Identification (Basic Stock Form)

General Material Classification
AMS or Code Designation
Composition

Material Processes (Basic Stock Form)

Melt Practice
Heat Treatment
Manufacturing Processes (case, forge, roll, extrude, etc.)

Test Specimen Description & Fabrication

Specimen Configuration (including notch if any)
Specimen Dimensions (overall and critical section)
Notch Factor, K_t
Fabrication - materials, methods & equipment
Surface Conditions and/or finish

Pre-Test Conditioning - Processing

Atmosphere
Temperature
Time
Stress

Pre-Test Specimen Condition

Describe or indicate significant changes in specimen condition resulting from pre-test conditioning or processing if available.

Figure 4. Descriptive Information - Mechanical Properties of Metals

Test Conditions and Procedures

Grain Direction - in relation to specimen major axis
Specimen Orientation - in relation to applied load
Load Rate - strain rate, head travel, velocity, etc.
Temperature
Time
Atmosphere
Equipment
Instrumentation

Failure Description, Results and Post-Test Measurements

Mechanical Properties - see Test-Properties
Failure Description
Failure Criterion

Test & Properties

Tension

Ultimate Strength
Yield Stress
Proportional Limit Stress
Modulus of Elasticity (Youngs or Tangent)

% Elongation
% Reduction in Area
Poisson's Ratio

Compression

Ultimate Strength
Yield Stress
Proportional Limit Stress
Modulus of Elasticity (Youngs or Tangent)
Poisson's Ratio

Bearing

Ultimate Strength
Yield Stress

Figure 4. (Cont'd)

Test & Properties (Cont'd)

- Edge Distance Ratio, e/D
- Bearing Hole Diameter to Thickness Ratio, D/t

Shear (& Torsion)

- Ultimate Strength
- Yield Stress
- Proportional Limit Stress
- Modulus of Rigidity

Impact (Izod, Charpy, Tensile)

- Impact Strength

Creep & Creep Rupture

- Applied Stress
- Rupture
- Rupture Stress
- Total Deformation @ Rupture or End of Test
  - Initial Deformation
  - Incremental Measurements of Deformation, Area Change (%), and Time
  - Total Area Change %

Other Properties

- Hardness & Test
- Grain Size & Number
- Density

Figure 4. (Cont'd)

APPENDIX II

THERMOPHYSICAL PROPERTIES RESEARCH CENTER

PURDUE UNIVERSITY

The Thermophysical Properties Research Center (TPRC) was established by Purdue University in 1957. It is a specialized center for information in depth on the thermophysical properties of all matter. Available recorded information on the thermophysical properties, including the theoretical methods of determining the properties and the experimental techniques used in measurement, are collected. The Center's major areas of activity are scientific documentation, data tables ("Critical Tables of Properties"), and, to fill in gaps and resolve discord, experimental research. TPRC has approximately twenty-five sponsors. The Staff is twenty-four people with backgrounds in chemistry, engineering, mathematics, metallurgy, and physics. TPRC has a thirteen-language capability. Early in 1963, TPRC will occupy a new building with expanded facilities for both experimental and theoretical research. Concurrent with the relocation, TPRC will become a separate unit of the Purdue schools of engineering.

Acquisition

Recorded information is obtained from the abstracting journals (pure and applied sciences), governmental and industrial research reports, private research institutions and universities' reports (including Doctoral and Master's dissertations), major research centers throughout the world having an information exchange agreement, special collections, compendia, reference works and the more obscure sources of information. The most extensive and readily accessible source of literature references is from the abstracting journals. Only a small number of the many abstracting journals published are selected and read. Of the nearly seven-hundred abstracting journals currently published, about twenty-five are selected as representing the area of interest to TPRC. Fourteen of these are systematically read and the remainder are irregularly monitored. Thereby a coverage of approximately 15,000 technical and scientific journals is obtained. The publications "Dissertation Abstracts" and "Masters Theses in the Pure and Applied Sciences" are used to obtain coverage of academic dissertations.

System

The organization of thermophysical information at TPRC is based on SUBSTANCE CLASSIFICATION. Fourteen information fields are established:

1. Property
2. Substance class
3. Substance name
4. Physical state
5. Type of subject coverage (theoretical, experimental, property values, etc.)
6. Temperature range
7. Language of original article
8. Serial number of reference
9. Journal name
10. Journal volume
11. Journal number (serial number with a volume)
12. Journal series
13. Beginning page number
14. Journal year

It is to be noted that items 8 to 14 pertain to the source of the abstract or article. In reference to item 1 above, there were 47 thermophysical properties contemplated. Those of interest include only 25. Thirteen properties are being covered, and the following seven are being coded:

1. Thermal conductivity, accommodation coefficient
2. Specific heat at constant pressure
3. Viscosity, fluidity
4. Emissivity, absorptivity, reflectivity, transmissivity (total and spectral)
5. Diffusion coefficient, permeability
6. Thermal diffusivity
7. Prandtl Number

Substances are classified and coded. The specific classifications are:

1. Works not involving substance class
2. Substances described by chemical formula
3. Ferrous metal alloys
4. Non-ferrous metal alloys
5. No chemical formula; no metal alloy

Indexing

Techniques were developed whereby only a small percentage of the pages of a report are read to obtain a maximum amount of information. The abstracters locate and mark pertinent references in the report and record the location on an "Abstract Search Record Card". Each document has a card on which the references to parts within it are recorded in the column identifying the property on which reported.

The pertinent references are then extracted, numbered, and placed in folders for final processing and filing. Code numbers are assigned to the items of information selected. Each selected abstract is coded on a "Reference Coding Form", one or more cards being required.

A further breakdown of the codes describing substance class and substance name follows:

Series 000:	works not involving substance class such as surveys, reviews, apparatus, theory, patents, etc.
Series 100 & 200:	substances described by chemical formula
Series 100:	elements and compounds (except compounds containing both C & H)
Series 200:	compounds containing both C and H
Series 300:	ferrous metal alloys
Series 500 & 600:	commercial and natural products

Information from the Reference Coding Form is punched on cards for machine usage. The punched cards are sorted by property, by class within property, and by substance within class. Information pertaining to each property is stored on a separate tape. If cards constitute initial storage for any one property, the information is stored on magnetic tape in same sequence as cards. If cards constitute a new set of information to be stored subsequent to initial storage, the ordering of the cards permits new material to be stored on tape in proper location based on property, class, and substance.

Information is referenced in TPRC publications termed "Retrieval Guide to Thermophysical Properties Research Literature". The Retrieval Guide gives in detail the procedures for the substance classification, mechanical

storage and retrieval. It reports numerical data, research on theory for these properties and experimental techniques to observe these properties, major reviews, compendium, etc.

Retrieval

Abstracts themselves have not been stored for machine retrieval.

Retrieval of bibliographic listings and source abstract locations is provided for by TPRC, using machine search and retrieval or through coordinated use of the book forms of its file known as "Retrieval Guide to Thermophysical Properties Research Literature". Through the coordinate use of the three books of the Guide, the user can make any query within the scope of TPRC's activities and quickly obtain an answer. The user enters the "Guide to Substance Classification and Code Descriptions" (book 1) to locate code number (class and name) for substance in question and obtains a property code whereby he identifies the properties on which information is available. The "Classified Search Index" (book 2) is entered using this code number to select serial numbers of those entries that are pertinent to his query. In the "Master Bibliography and Author Index" (book 3) he finds the bibliographic citation of each reference of interest. Machine search and retrieval is initiated by placing the desired search parameters on a search card which is then used to search for these requirements in the computer. An address directory at the head of the magnetic tape locates area of tape where desired substance is located and all the entries in that area are checked against the parameters given on the search card by a modified set-intersection method. When pertinent items are located, the serial number of the entry together with the other descriptive code numbers of the bibliographic information are punched out on cards by a computer. These cards are then fed into a tabulator which lists the answers to the query.

Dissemination

In 1961, TPRC published the "Retrieval Guide to Thermophysical Properties Research Literature" consisting of a set of three books, a total of 1900 pages, presenting source information on seven thermophysical properties of 14,250 substances and materials. Volume II, to be published in June 1963, is estimated by TPRC to bring the coverage of work to 43,525 referenced entries covering the world literature contributed by approximately 10,500 authors. There will be 19,070 substances reported. Journals, reports, and books cited (cumulative) are 2,420, covering the initial 13 of an originally contemplated 47 thermophysical properties. There are three parts:

Part A Guide to Substance Classification and Code Descriptions (series, property code, substance name code) (Prepared manually)

Part B Classified Search Index (substance class, name, physical state, subject language, year, serial number) (Prepared by digital computer and IBM 407 tabulation from cards)

Part C Master Bibliography (title of paper, author; journal-volume, pages, year; abstract-volume, column; serial numbers of all author's publications)

Author Index (author and code number)

(Prepared by IBM 407 tabulation from cards)

It is anticipated that Volume III will follow in June 1963 and that it will have reported nearly all of the world's literature (back to 1920) on the first seven of the thirteen properties initially being covered on all matter.

Tables of the "most probable" values for each property have been prepared as "Critical Tables of Properties". Recommended "most probable" values are normally accompanied by graphical representations comparing these values with available experimental data. TPRC's data tables consist of three volumes, namely:

Data Book, Vol. 1	Metallic Elements and Their Alloys (gaseous, liquid, and solid states)
Data Book, Vol. 2	Nonmetallic Elements and Their Compounds (gaseous and liquid states at normal temperature and pressure)
Data Book, Vol. 3	Nonmetallic Elements and Their Compounds (solid state at normal temperatures and pressure)

Data sheets, consisting of both revisions and new additions, are released in June and December of each year.

As of January 1963, the following data table projects have been initiated:

1. Thermal Conductivity:	all metallic and nonmetallic elements, their alloys and compounds in solid, liquid and gaseous state
2. Emissivity, absorptivity, reflectivity:	all metallic and nonmetallic elements, their alloys and compounds in the solid state
3. Viscosity:	selected gases, vapors and liquids of technical importance

Machine Operations

IBM 1401 used for listings.

IBM card handling equipment consisting of punches, verifiers, sorters, reproducers and tabulators.

IBM 7090 scheduled for installation in 1964.

APPENDIX III

ELECTRICAL AND ELECTRONIC PROPERTIES OF MATERIALS

HUGHES AIRCRAFT COMPANY

The Hughes Aircraft Company, Culver City, California, is currently under contract to the Air Force, Directorate of Materials and Processes, Aeronautical Systems Division (Materials Central), Wright-Patterson Air Force Base, on contract AF 33(616)-8438 for an information retrieval program for the subject materials. Work on this contract began 5 July 1961. The program includes plans for coverage of ten major categories of materials: semiconductors, insulators, ceramics, ferro-electric dielectrics, metals, ferrites, ferromagnetics, electroluminescent materials, thermionic emitters and superconductors. Emphasis during the first year had been upon semiconductors and insulators with other categories to be added as the program develops. The stated aim of the Company is to provide ready access to electrical and electronic property data of all materials important in today's technology.

Acquisition

The Company states that about one-third of the literature selected on the basis of a promising title and/or abstract is rejected upon appraisal. Documents on insulators and semiconductors extend back to 1940. Their search for insulation materials and semiconductors during the first year was largely concentrated in a few remunerative sources including:

1. ASTIA Technical Abstract Bulletins
2. Ceramic Abstracts
3. Chemical Abstracts
4. Digest of Literature on Dielectrics
5. Engineering Index
6. Electrical Engineering Abstracts
7. Nuclear Science Abstracts
8. Physics Abstracts
9. Semiconductor Abstracts
10. Semiconductor Electronics
11. Solid State Abstracts
12. U. S. Government Research Reports

Thirty-thousand titles and abstracts were appraised the first year. Estimates, as of 15 June 1962, were that 80% of semiconductor literature and 70% of insulating materials literature has been searched and that the retrospective

documentation of the semiconductor category was 60% complete and for the insulation materials category 50% complete. Data selected are those judged most representative, precise, and reliable covering the widest range of variables. When data compilation of a material is made, a subject specialist compiles the assembled literature.

System

A documentation system has been established for abstracting, indexing, storage, and retrieval of data on semiconductor materials and on insulating materials. A modified coordinate indexing system is used which is immediately available as a manual system and is adaptable to automation of data storage and retrieval. The system uses "precoordinated" descriptors of one material or one material and one property. "Use" references are employed, i.e., "See," "See Also," and trade names. Categories and sub-categories have been established. There are cross-references to properties of the material of the particular category. Elements, compounds (organic and inorganic), mixtures, and systems are in the array of materials. Compounds are listed alphabetically.

The system is specific and has the advantage of quicker retrieval than one of unit terms. Usually only one card with the "precoordinated" descriptor has to be consulted. A lower density of posted articles or documents under a given term is obtained. The system can be manipulated only through materials, not through properties.

Indexing

The Index consists of an Accessions File (card) and a Descriptor File (card). Accessions cards are arranged numerically by the accession number assigned each document. On each card is the bibliographic entry, property data, abstract of its document, and tracings of headings under which the document was indexed. The Descriptor File is divided into major categories of materials. Descriptor cards carry their subject and the accession numbers of all documents containing data on that subject. Accession numbers are posted on pertinent descriptor cards in vertical columns as determined by terminal digit using an IBM 1401. Arrangement is alphabetical by material name within each category and by property name within the material name.

There are two distinct sets of punched cards, the Master (material or material and property) and the Detail (accession number--article). The master card provides the printout of the descriptor on the descriptor card. Each descriptor card has a punched master card. The detail card carries the accession number of the article or document. For each document there is a detail card for each of the descriptors assigned. These cards are filed behind the

applicable master card. Thus behind each master card are detail cards representing documents indexed under that descriptor by accession number.

Card files are maintained under author, source (publisher), and accession number. They serve to prevent duplication and give cumulative bibliography and sources information.

Forms and cards used were mainly as follows:

1. Accessions Card (figure 5),
2. Index-Abstract Form,
3. Descriptor Card,
4. Abstract Card,
5. Data Sheet (Curve),
6. Data Sheet (Tabular), and
7. Data Sheet (References).

A Glossary of the index terms is compiled and established by technical personnel. A selected item or document is assigned an accession number. The Index-Abstract Form is completed on the material. Index-Abstract Form for Insulating Materials (Figure 6) and a similar form for the semiconductor category of materials are used by the subject specialists during abstracting and indexing. It carries the accession number, bibliographic entry, material and property headings or names for material, and an abstract.

Lists have been established and prepared for assistance in indexing and retrieval as follows:

1. Properties and appropriate cross-references for semiconductor materials accessions,
2. Properties and appropriate cross-references for insulator materials accessions,
3. Semiconductor materials names,
4. Insulation materials names together with alternative forms and trade names,
5. Glossaries of selected properties and effects for insulating materials and for semiconductor materials, and
6. Key to Property Symbols for the particular category.

The subject specialists are provided the above lists, glossaries, keys to property symbols, and Guide for Abstracters (Figure 7). The Data Sheets are prepared from the compilation and evaluation of the best available experimental data on the material. A separate Data Sheet is prepared for each property or coefficient of a particular material. Data on Data Sheets are arranged in alphabetical order by property name within a material name. The last Data Sheet

(References) lists only references from which data have been taken. An Operations Flow Chart (Figure 8) illustrates the division and tasks of the major activities.

Retrieval

Retrieval of information is accomplished by choosing material or material and property of interest, then, singly or by matching, picking out the accession numbers on the relevant subject descriptor cards. The accession numbers found common identify the documents containing the properties for which search is made.

Dissemination

Materials Central is furnished the following system components:

1. Accessions File
2. Abstracts File
3. Descriptor File
4. Reproduced Articles
5. IBM cards used in IBM 1401 program.

Many data sheets have been published. Publication of property tables, bibliographies, surveys of current research and reviews of subject areas is contemplated in the near future. Abstract cards can be provided.

Machine Operations

The data processing system can print lists of materials and/or properties. Monthly updating of descriptor cards includes printing of an up-to-date tab run of all materials. Equipments used are sorters, collators, reproducers, interpreters, card printers, tabulators, and IBM 1401.

If a computer approach were to be adopted for storage and retrieval of the indexed information, the punched cards, which are a by-product of posting, could provide input information.

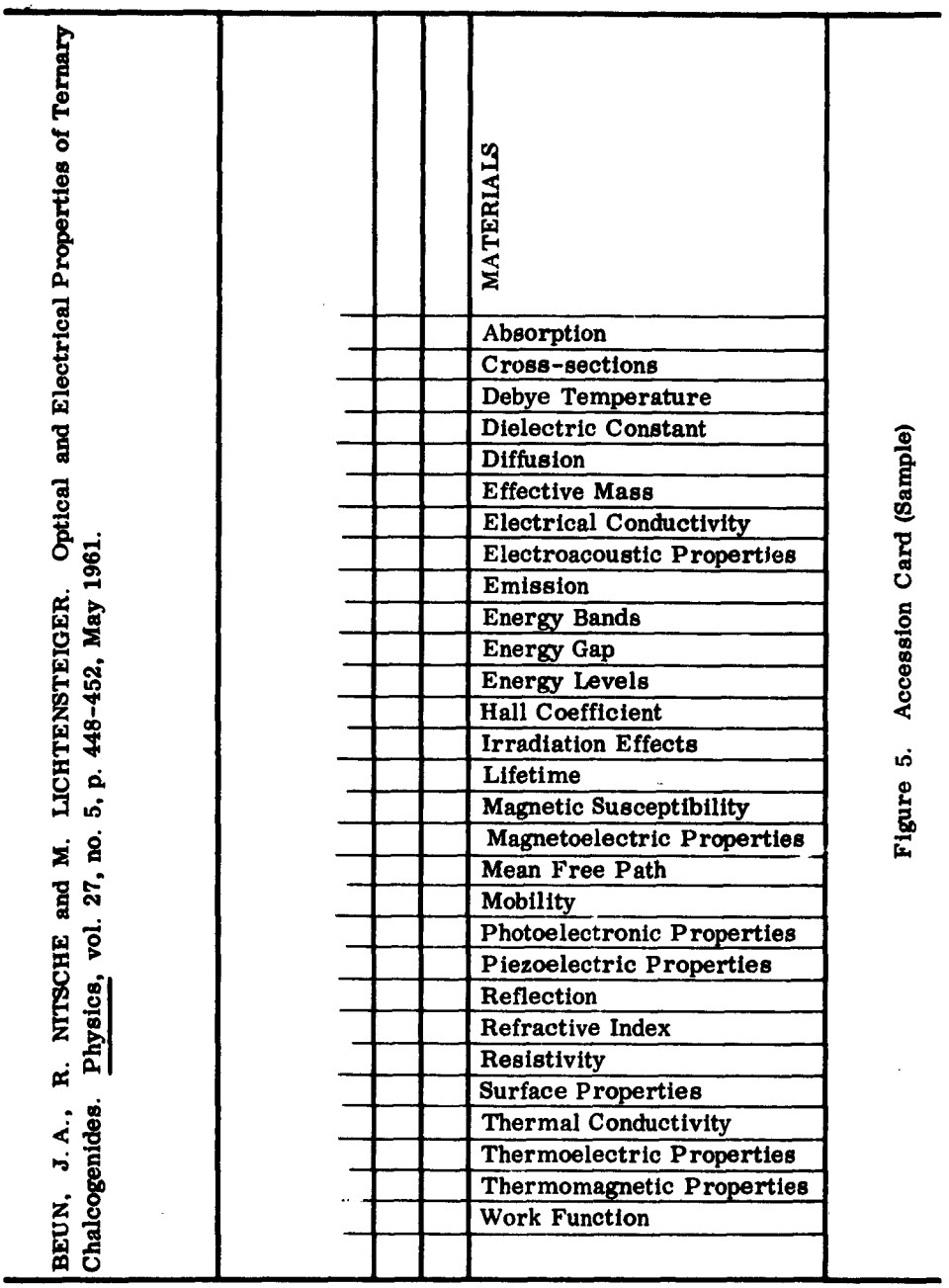


Figure 5. Accession Card (Sample)

Materials:	
_____ Arc Resistance	_____ Irradiation Effects
_____ Corona Effects	_____ Loss Factor
_____ Dielectric Constant	_____ Power Factor
_____ Dielectric Strength	_____ Storage Factor
_____ Dissipation Factor	_____ Surface Resistivity
_____ Insulation Resistance	_____ Volume Resistivity

ABSTRACT:

AF 33(616)-8438 Index-Abstract Form (Insulators)

GLA: 1326 900 02 24 Name _____ Hours _____ Date _____

Figure 6. Index-Abstract Form for Insulating Materials

(1) Each piece of literature supplied for abstracting is accompanied by an Index-Abstract form which contains the bibliographic entry, a list of property names, a space for beginning the test of the abstract, the GLA code to which time spent is to be charged, and spaces for names of abstracter, hours spent (to nearest 1/10th of an hour) and date.

(2) The abstracter will enter the names of the materials covered in the literature, check the relevant property names, and provide a legible text sufficiently explicit and detailed for comparison and evaluation of the data given with like data from other literature.

(3) In order to provide a uniform input and facilitate future evaluation it is suggested that abstract texts be divided into three general topics:

(a) Materials and Sample Preparation,
(b) Apparatus and Method,
(c) Individual Properties.

The Materials and Sample Preparation section contains detailed information on the specific materials tested or evaluated or indicates the lack of same. Include any information which will clarify the graphs and tables.

The Apparatus and Methods section contains a description of the names and types of apparatus used in performing the tests. Again, lack of specification should be noted.

The Individual Properties section cites the tables, charts and graphs and provides statements useful for future comparison and evaluation.

(4) The charts and tables cited in the abstract should be indicated with arrows in the margins of the literature text. Equations which, like the graphs and tables, may be cut out and pasted up, may be cited in the abstract text by a circled number (e.g., ④ , and in the body of the literature by the same circled number with an arrow (⟶) in the margin. This will obviate copying out such information.

(5) Articles which are found to contain no data or reviews of data useful for the purposes of the project may be rejected. In such cases write, "No useful information" after the word ABSTRACT: on the Index-Abstract form.

Figure 7. Guide for Abstracters

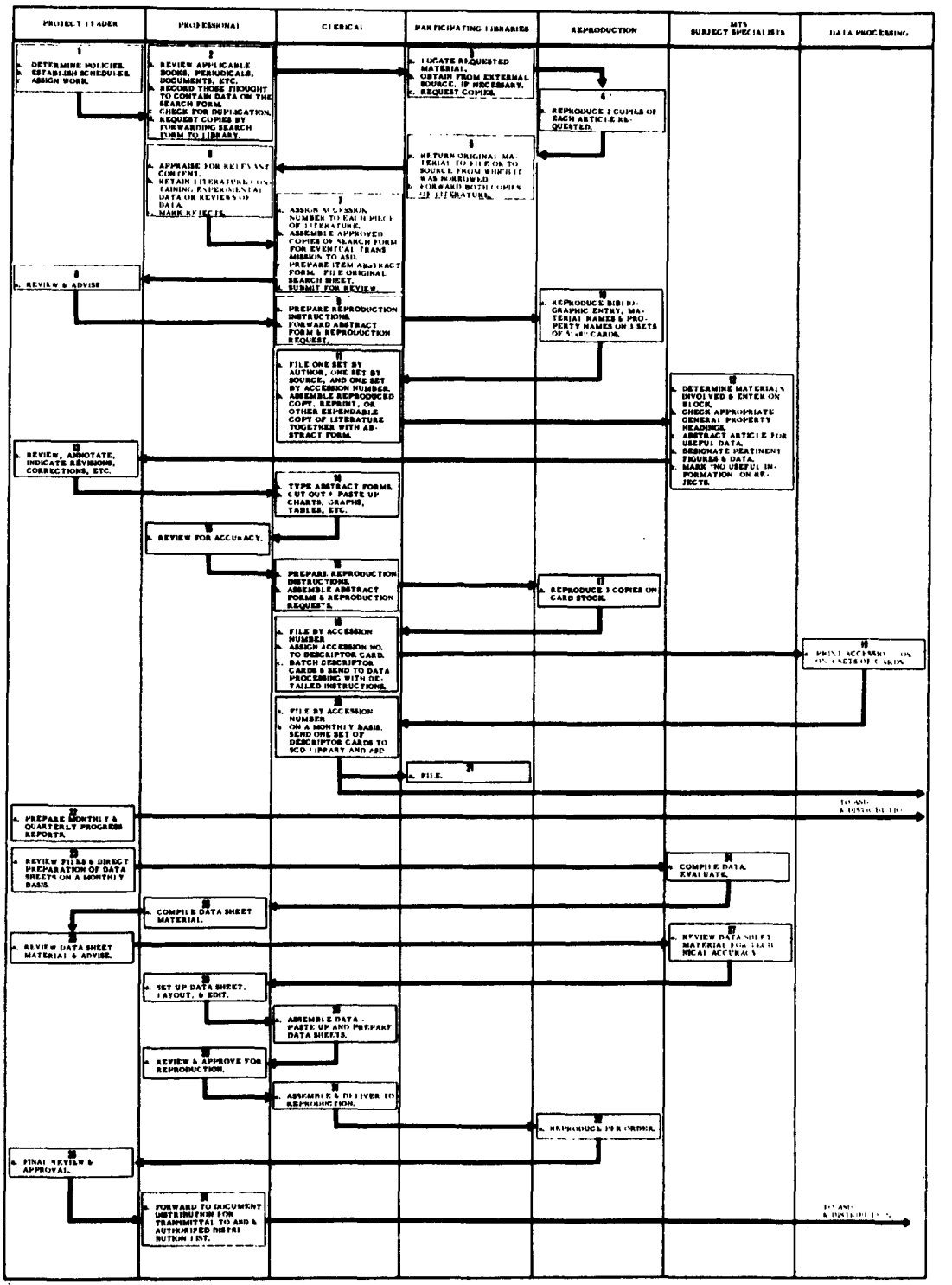


Figure 8 Operations Flow Chart

APPENDIX IV

MATERIALS CENTRAL - UNIVERSITY OF DAYTON

The University of Dayton Research Institute (UDRI) under the sponsorship of the Information Processing Section, Applications Laboratory, Directorate of Materials and Processes, Aeronautical Systems Division, Wright-Patterson AFB, Ohio, is under Contract AF 33(616)-7698, for the development of a system for the storage and retrieval of materials-reports and documents.

Materials Central's concern is with adhesives, ceramics, cermets, coatings, elastomers, fuels, lubricants, electrical and electronic materials, fibrous materials, metals, oils, plastics, polymers, and various types of manufacturing procedures and methods.

Acquisition

Documents are obtained in the form of reports resulting principally from studies sponsored by ASD. Other sources of input are limited although some reports from Army, Navy, and aerospace companies are acquired. Documents are received at the rate of approximately 350 per month. The Information Processing Section is on many distribution lists through the Department of Defense. There is no active program for acquiring documents at the University of Dayton. No particular effort is made to screen all accession lists from such sources as Defense Metals Information Center (DMIC) or Armed Services Technical Information Agency (ASTIA) by UD. Several abstract journals and similar publications covering both domestic and foreign articles are consistently reviewed by Materials Central and pertinent material obtained and transmitted to UD. Clerical personnel in the library examine incoming documents. Accession numbers are assigned those accepted for input. The material that currently is not being indexed includes bibliographies, handbooks, symposia proceedings, work in progress, information processing data and test results.

System

The program began in December 1960. The first two months were devoted to reviewing literature on information storage and retrieval. The system established is a "concept-coordination" system using "links" and "roles," and "deep indexing". A standard inverted file is used. "Links" are used to subdivide documents into ideas while "roles" are used to indicate semantic functions of the indexed ideas or words. A link is defined by UD as a stylized statement. Several are produced per document. These stylized statements

provide a content description of the document, and, if properly developed, could form an abstract of the document. Materials Central personnel regard "links" simply as associations between related terms, with stylized statements being an aid to new indexers in organizing the material, and several closely associated statements are frequently combined in one "link." "Links" are employed as an aid in the reduction of "false drops" by eliminating the possibility of a key word of one statement being erroneously associated with a key word from another statement of the same document. "Roles" are used to overcome the problem of a given key word having different uses or meanings in various statements. To date, thirteen "role" definitions are used.

Indexing

Indexing of all documents, except for classified documents, is accomplished by the University of Dayton. The documents are obtained directly from Materials Central. Indexing is done on the entire content of the document. Technical personnel prepare abstracts if they are needed (either as a result of a rewrite requirement or if abstracts are missing). The concept of "links" and "roles" is employed by the indexer. After dividing a document into its stylized statements, a link (an alphabet letter) is assigned to each statement and that link becomes associated with each key word of that statement. Where a problem of semantics arises regarding a given key word, a role (a number), which represents a predetermined use of the term, is assigned to that key word. As of the end of December 1962, over 7,000 documents had been indexed but only 5,300 documents had been forwarded to key punch for entry into the system.

Technical personnel perform indexing and, by exchange of work, review and edit indexing. Indexers comprise a chemical engineer (M.S. Ch.E. degree), a metallurgist (BS degree), and a full-time chemist (BS degree), none of whom had indexing experience prior to joining the staff. The chemical engineer and metallurgist were given on-the-job training by personnel of the Information Processing Section, Applications Laboratory. The University of Dayton has developed in-house capabilities for the training of additional indexers. Two students are used for card pulling and other routine tasks to support the indexing team. Uniformity of indexing is sought by requiring review indexers to review all indexing to assure its completeness, adherence to basic ground rules of indexing and uniformity of action on situations not covered by ground rules. The edit phase consists of the generic posting of terms and other various reference postings. "See" and "See Also" references are used in the Thesaurus to indicate synonyms and near synonyms.

An early editorial decision was to make most materials plural, especially materials which were "parent" term. This was of assistance in determining whether a term was a material or a process.

Links are being used in the concept coordination system with the thought that they will aid in the reduction of false drops by permitting the retrieval of only true combinations of terms or ideas. The use of links requires the indexer to subdivide a document into its various intellectual ideas and apply a new link (merely a letter of the alphabet) to each idea. Application of roles makes it necessary that the indexer be provided with as complete a listing of role definitions as possible.

A preliminary outline of indexing ground rules (in preparation) is shown in Figure 9. A sample of the index cards used is shown in Figure 10. The University of Dayton edits the vocabulary resulting from indexing. All terms included in their vocabulary have not been obtained directly from the documents. Their indexers are free to generate terms that are either inferred from or implied by the document contents. Tabulation of the index is prepared periodically and distributed to various sections throughout the Materials Central. A dual dictionary is being prepared for at least two purposes: (1) providing manual searches away from the University, and (2) serving as a model of the over-all system from which further improvements could be made. A rough draft of a dual dictionary has been prepared based on the vocabulary derived from approximately 500 documents. This dictionary does not suffice for indexing purposes, and additional terminology is being developed. Subsequent to the preparation of the rough draft, further vocabulary has been developed from 2,000 documents with an additional 1,000 documents partially completed. A yield of close to 9,000 terms is expected from the 2,000 documents from which a thesaurus is being prepared. The Thesaurus will represent a key to the terms in the dictionary. The terms can be used to rephrase search questions, if necessary, in terms of the system's vocabulary. The editing of the vocabulary generated through the indexing of approximately 3,000 documents has been completed. The Thesaurus will contain approximately 10,400 terms.

A flow chart of over-all operations is shown in Figure 11.

Retrieval

Retrieval is accomplished through the use of the tabulated index. The Thesaurus and dual-dictionary, which are scheduled for production in early 1963, will reference some 6,000 - 7,000 documents and will provide searching tools.

Several inquiries have been made of the system, but since there is no formal searching tool as yet, these searches have of necessity been rather informal and incomplete. One inquiry made to the system was on the subject of "whiskers" (elementary crystal growth formations) and five or six selections were obtained. Types of questions to be answered by the Center are unknown at

this time. No study has been made, either at the University of Dayton or at Materials Central, to suggest user profiles or areas of user interests.

Dissemination

Copies are made of pertinent graphs, tables, and descriptive passages, if desired. Reports are not generally available. Use of ASTIA's facilities is encouraged if copies of entire reports are required.

Machine Operations

Indexing entries are keypunched and verified. One card per term-entry is provided. A sorter and tabulator are used to provide an alphabetically arranged listing following which a manual edit and purge operation is performed.

The tabulation of the cards will be eliminated as soon as a vocabulary tape has been prepared for the NCR 304 computer. The computer will be programmed to reject and tabulate terms that are not in the vocabulary. Only those terms will require review by the editing team.

An NCR 304 computer is used for the tabulation of the vocabulary for editing purposes. A routine has been programmed for preparation of a dual dictionary on the NCR 304, but this routine has been used for only a very short time. A further routine, using the NCR 304, is programmed for preparation of a thesaurus which will be distributed by the time this report is published.

Machine functions used: key punching, sorting, tabulator, and computer programming. A standard 80-column IBM card is punched for each link-role-term combination on the index cards in the following manner:

Columns	Description
1 - 7	Document Accession Number
8 - 9	Link Designator
10 - 11	Role Designator
12 - 19	Term Code (assigned during computer processing)
20 - 79	Term

I. DESCRIPTION OF UNIVERSITY OF DAYTON INFORMATION RETRIEVAL SECTION
- A. Function
- B. Operations
- C. Utility

II. INPUT PROCESSING
- A. Indexing
  - 1. Philosophy
  - 2. Personnel
  - 3. Flow Sheet
- B. Review Indexing
- C. Editing

III. INDEXING
- A. Evaluation of Document
- B. Organization of Information
  - 1. Definitions
    - a. Links
    - b. Roles
    - c. Multiple word terms
    - d. Phraseology
  - 2. Transformation of Stylized Statements into Terms
- C. Roles
  - 1. Meanings
  - 2. Usage

IV. TRACING SHEET
- A. Transcription of Terms
  - 1. Printing
  - 2. Script
- B. Format
  - 1. Replica
  - 2. Heading
  - 3. Body

V. GENERAL RULES
- A. Criteria for Selection of Terms
  - 1. Descriptiveness
  - 2. Appropriateness
  - 3. Applicability
  - 4. Generation of New Terms
    - a. Multiword terms
    - b. Extension to related field
    - c. Implied terms
  - 5. Objectives
- B. Temperature Ranges
- C. Abbreviations
- D. Trade Names
- E. Military Specifications
  - 1. Qualification
  - 2. Material designation
- F. Grammatical
  - 1. Plurals
  - 2. Dual-meaning words
  - 3. Noun-form vs. verb-form

VI. METALLURGY

VII. CHEMISTRY

VIII. PHYSICS

Figure 9. Preliminary Outline of Indexing Ground Rules

Access No. 12977P Title Reduction and Consolidation of Superior Quality Molybdenum Alloys	
Author(s) S. Christopher; J. Wong	
Indexer CLB (JMT) Date 6 Apr 62 (Reindex Date)	
L-R L-R L-R	Terms
Z-	Wah Chang Corp
Z-	D-0861
A-2	Forging
A-2	Swaging
A-9	Recrystallization Temp.
A-11 B-11	Single Crystal
A-11 B-11 C-11	Molybdenum
B-2 D-2	Heat Treatment
B-1	Temp. 090
B-9	Hardness
B-9 D-9	Microstructure
B-	Swaged
C-8	Extrusion
C-1 D-1	Temp. 130
C-	Hydrogen - Reduced
C-	Electron Beam Melted
C-	Arc Melted
D-1 B-1	Temp. 110
D-9	Tensile Strength
D-9	Yield Strength
D-9	Elongation
D-9	Bend Ductility
D-11	Sheet
D-11	Molybdenum
D-9	Recrystallization

Figure 10. Index Card (Sample)

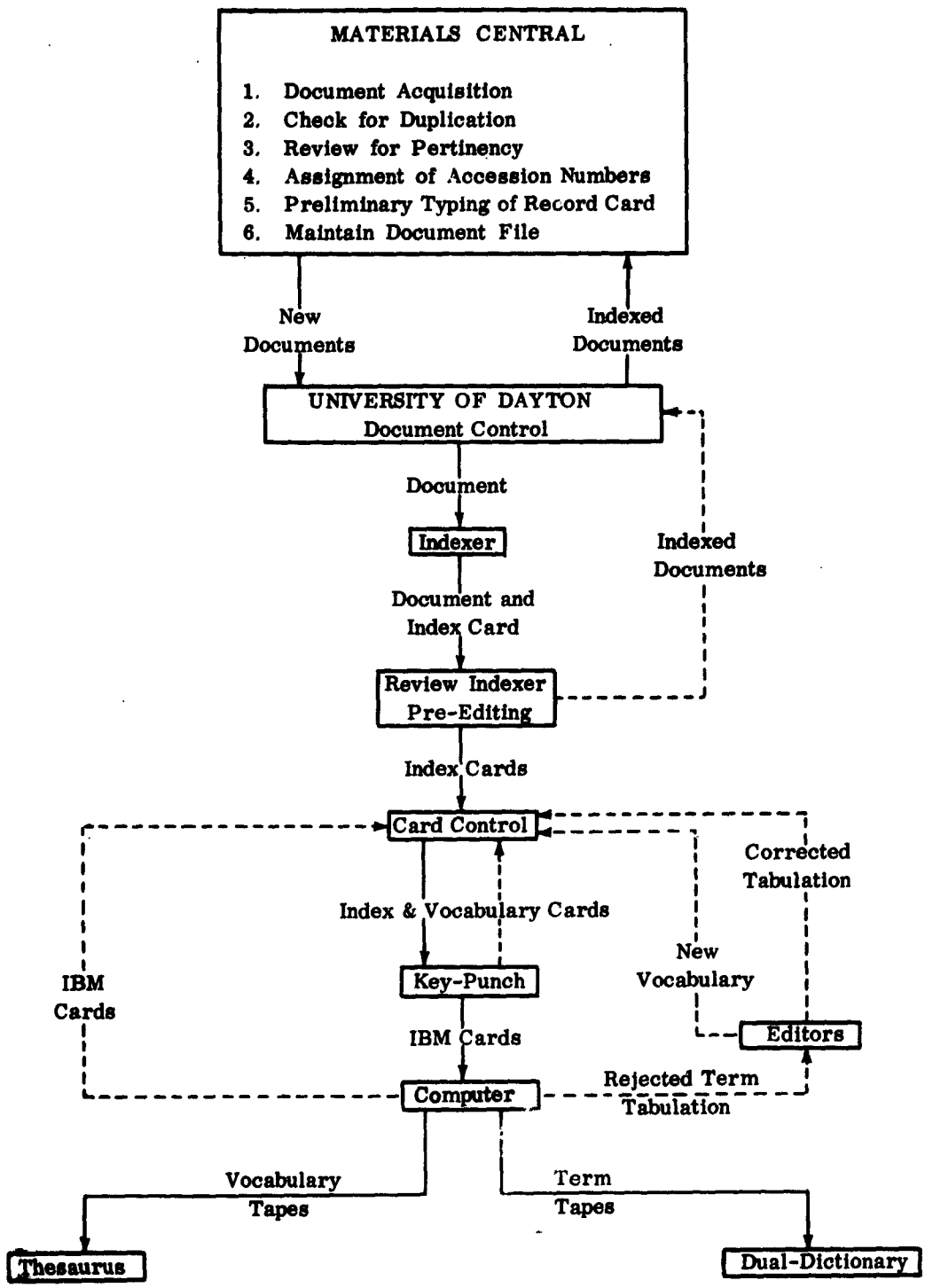


Figure 11. Data Flow Chart

APPENDIX V

SYRACUSE UNIVERSITY RESEARCH INSTITUTE

The Syracuse University Research Institute completed a survey study on information requirements for application of non-metallic structural materials to aerospace vehicles. The aerospace industry and agencies were studied to determine which materials, properties, and problem areas in non-metallics existed, and which methods to employ for making information available to the designers. It was concluded that a Design Handbook or Manual on non-metallic engineering materials was essential and that it would benefit the aerospace field. The investigation was limited to non-metallic structural (load-bearing) materials. The project was sponsored by the Air Research and Development Command, USAF, on contract no. AF 18(600)-1876.

In general, the findings were that (1) non-metallic materials were not used to full advantage, (2) there was little information on these materials in literature, (3) data were confusing in that correlation was lacking and tests and procedures were not standardized, and (4) data over broader ranges were needed. Thus, the major problem was the correlation of non-metallic structural materials data disseminated by a wide variety of sources and obtained under widely varying conditions.

On Materials Central contract no. AF 18(600)-8780, Syracuse University Research Institute has undertaken the task of obtaining, organizing and correlating data on non-metallic engineering materials for compilation into a Materials Design Handbook for aerospace vehicle design work specifically for Air Force applications. The Handbook will have the following divisions:

I. Structural Plastics
II. Structural Adhesives
III. Structural Ceramics
IV. Other Structural Non-Metallics
V. Structural Combinations of Metallics and Non-Metallics
VI. Secondary Structural Components
VII. Non-Structural Applications (Insulations, Coatings, etc.)

The divisions are subdivided into Manuals to facilitate use. Manuals of Division I. Structural Plastics will be as follows:

IA. Introduction
IB. Basic Design
IC. Primary Materials and Their Properties

ID. Material Systems and Their Properties
IE. Theoretical Stress Analysis
IF. Processes and Tooling
IG. Testing and Quality Control

Initial work has been on the elemental structural applications of reinforced plastics, namely, laminates and wound open end cylinders. Manual IB - Basic Design, which covers the various structure types and their application will have the following sections:

Introduction
Design Considerations
Primary Materials Summary
Materials Systems Summary
Stress Analysis
Processes
Tooling
Testing and Quality Control

Within the manual there will be this sectional coverage on each specific structural type correlated.

Procedures for data handling include a flexible coding system using large style McBee Keysort cards and having a Bibliographic Reference File and a Specific Data File. The Bibliographic Reference File has the source, data, and type of data available. The Specific Data File, using the Keysort Cards, has information in detailed classification on material, property, test method, and various other items.

Acquisition sources of information are the Government, Industry, and individuals; research activities, designers, users, fabricators and producers. Data are obtained from articles and individual pieces of information, material and process specifications, test data and reports, books, periodicals, company libraries and through correspondence. Visits are made to agencies and companies.

APPENDIX VI

ARMED SERVICES TECHNICAL INFORMATION AGENCY

The Armed Services Technical Information Agency (ASTIA) was established May 14, 1951, as a centralized technical information center for the Armed Services, by a Directive issued by the Secretary of Defense. Its mission is to provide faster and more effective service to the engineers and scientists of the defense community of the United States. Accordingly, ASTIA's objective is to provide, through automation, a comprehensive bibliographic information and announcement service in such a manner that the scientist or engineer can have at his fingertips, at any given time, information in the ASTIA collections pertinent to his needs. This agency is the principal documentation center for unpublished scientific and technical reports which are issued as a result of, or relate to, research and development projects of the Department of Defense (DOD). The program is confined to information emanating only from DOD, industries, universities, and other research institutions generating information through Defense contracts, Atomic Energy Commission, Central Intelligence Agency, and National Aeronautics and Space Administration, but does not include scientific information generated by other sources outside of the Federal Government, other than in exceptional cases. It maintains and cross-services all of the research and development contracts with private concerns for the Army, Navy and Air Force. Also, ASTIA has been assigned program management responsibility for providing a centralized source for the correlation and retrieval of research, development, test and evaluation (RDT&E) program information for DOD. The system for retrieving RDT&E information is compatible with that used for their technical documentation.

One of the largest collections of scientific and technical reports in the free world has been acquired by ASTIA. The major part of the Federal research and development during and since World War II has its results reflected in these reports. In fiscal year 1962, there were in excess of 630,000 documents in the collection of which roughly 300,000 were in the computer system. The present annual rate of approximately 40,000 documents is rapidly accelerating, and 100,000 is anticipated in the near future. Daily over 4,000 requests are made for reports. ASTIA serves approximately 700,000 scientists, engineers, researchers, and technical librarians of the military research and development community. The budget authorization for fiscal year 1963 is approximately $4,437,000.

Reports accepted and cataloged into the system are assigned a document control number (AD number). They are reviewed and analyzed as to scientific subject matter in accordance with the Thesaurus of ASTIA Descriptors. Document files are arranged numerically by the accession number. The indexes

are organized by subject matter, source, and contract number. The procedures provide for data coordination and retrieval, document retrieval, announcement of new document accessions, and production of indexes, thesauri, and special-interest bibliographies.

ASTIA catalogs, abstracts, indexes, and stores military classified and unclassified scientific and technical reports; catalogs their availability; releases them upon receipt of requests in support of defense projects; provides bibliographic services and develops documentation standards in coordination with other Federal agencies.

ASTIA has an integrated data processing system providing (1) automatic request validation to determine the need-to-know and security of the non-military user, (2) automatic inventory control, (3) accountability of both classified and unclassified documents, (4) mechanized quarterly and annually cumulative subject and corporate author indexes to Technical Abstract Bulletins, (5) automatic check for incoming documents to determine if they have been previously processed into the system, (6) automatic identification of documents to fill requests that do not cite ASTIA catalog numbers, (7) mechanized search and retrieval of information, i.e., the identification of documents and catalog number in the ASTIA system on any subject or combination of subjects, (8) random access capability, (9) automatic printout of catalogs and abstracting information.

The Thesaurus of ASTIA Descriptors, Second Edition (first revision), December 1962, has been published and issued. It is divided into three major sections, (1) Schedule of Descriptors, (2) Scope Note Index, and (3) Generic Relationships. The Schedule of Descriptors' section is comprised of (1) an alphabetical list of Descriptor Fields(26 in number) covering the ASTIA collection in terms of subject matter disciplines, (2) the Descriptor Fields divided into distinct Descriptor Groups (170 in number) indicating the extent of each Field, and (3) an alphabetical-numerical list of Descriptor Groups, displaying individual Descriptors within each Group.

The Scope Note Index section lists Descriptors and Use references in alphabetical order. Scope notes have been provided for descriptors wherever the original definitions were felt to be either not specific enough or too specific. Words of multiple meaning have been selectively defined. An annotated entry is displayed. Descriptors are upper case. Each is followed by the name of the Descriptor Group to which it belongs. In general, Also See references relating back to the same Descriptor Group are not given. Related terms can be sought in the appropriate Descriptor Group where an exhaustive listing is given. The Includes references are either smaller in scope than, or at most, no larger than the Descriptor with which they are associated. "Included" terms are never Descriptors, hence they are never in upper case. Also See references are always Descriptors, are in upper case, and are listed in their proper alphabetical order in the index.

Generic Relationships charts are a new feature in this edition. The charts display Generic Relationships for some Descriptors in terms of Specific to and Generic to entries. The listings are intended as aids to the analyst or bibliographer in determining whether or not the proper degree of specificity has been considered. Automatic generic indexing by machine will not be accomplished except for the case of organic chemistry where special rules apply.

All Generic Relationships displayed Descriptor-by-Descriptor in the Scope Note Index have been collected in chart form in an appendix. The Generic Charts total 78. They are indexed by number and also as to subject. There is no necessary relationship between these charts and the Field and Group structure.

Fields and Groups list the Descriptors for a given subject area on the basis of their definition and intended use by analysts and bibliographers, hence each Descriptor is placed in a Field and Group.

Displays of Generic Relationships list all hierarchical connections among Descriptors, regardless of other considerations and may extend beyond the logical confines of a Group. The charts of Generic Relationships constitute points of entry to the ASTIA vocabulary in addition to those by Field, Group, or Scope Note Index. The Generic Relationships conform to ASTIA's definition of the terms and do not cover all hierarchical relationships in any universal sense. Classification in the traditional sense is not implied.

Descriptors that exactly convey the desired concept can be sought in the Thesaurus. If they cannot be found directly, then a selection can be sought (1) from Use references which give the Descriptors of equivalent, similar, or broader meaning, or which stipulate the requirement of two or more valid descriptors, and (2) from combination of two or more valid Descriptors selected according to certain basic rules. Specifically, alloys are retrieved by designating each of the component parts of the alloy system. Inorganic chemical compounds are retrieved by designating the radical(s) or ion(s) that comprise the electropositive and negative parts of the molecules. Not all Descriptors are subject related. Abstract Groups list under (1) Abstract Concepts and (2) Modifiers, Descriptors representing concepts of abstract nature and utility. Organic chemical compounds are retrieved by designating the fragments (the functional groups and the substituted groups, radicals, or ions) of the molecular structure of the compound. The fragment Descriptors and specific guidelines for indexing organic chemicals are presented in the ASTIA Chemical Thesaurus, a supplement of the Thesaurus of ASTIA Descriptors. Compounds that have particular significance in other fields, including drugs and biologicals, enzymes, vitamins, etc., are indexed by the appropriate Descriptors when their chemical structure is not under study.

The ASTIA Chemical Thesaurus brings together chemical or related retrieval terms for biochemistry, organic chemistry, and metals and alloys. It is a tool for indexing and retrieving chemical documents. Terms reflect the revised method for indexing organic chemicals which involves separating the molecular structure into predetermined fragments which are, for most part, the common functional groups. Retrieval of chemical compounds is based on correlation of these same fragment descriptions. Chemical structures are coded into one format without the use of links, interfixes, or other devices for keeping information separated. A tableau of fragments for describing organic compounds indicates generic relationships among the fragments within each group and is graphic in that the fragments are depicted rather than the arbitrary names assigned to them. There are general indexing rules. A compound must be fragmented according to the rules before assigning Descriptors. Alphabetical listing is applied to specific compounds, chemical fragment names, rings, ring system names, reactions, processes, metals and alloys, and biochemical and pharmacological terms. Listed under Miscellaneous Terminology are terms (other than the names of the fragments, rings, and ring systems) in appropriate groups: alkaloids, drugs, and biologicals; alloys; enzymes; hormones; reactions and processes; and, vitamins. The Appendix has a partial listing of specific compounds in the alphabetized chemical dictionary under each of the fragments contained within their structures. The headings are halogens; carbohyl; COOR; S-Hetero; N-Hetero; C,N: N,O, (S); S, O(N); and Amines.

ASTIA issues a Technical Abstract Bulletin (TAB) semimonthly announcing the acquisitions to Department of Defense agencies, their contractors, and authorized Federal agencies. An alphabetized, annotated Subject Index has been added. Therein an entry is comprised of its title or a descriptive statement concerning the document, its AD number, and the number of the subject division where the complete announcement appears. There are two announcement portions of TAB, and in each, the entries on basic and applied research are grouped into 33 Subject Divisions. One portion (white paper) has reports announced which may also be made available for sale to the general public through the Office of Technical Services (OTS), U. S. Department of Commerce. The other portion (buff paper) lists unclassified citations for the classified reports, and those unclassified reports which, because of proprietary or reproduction limitations, cannot be made available for sale through OTS. Included in this portion is an additional division entitled IDEP (Inter-service Data Exchange Program) which has entries relating to test reports of components and parts of ballistic missiles and space vehicles. There are also an AD Number Index and Notice of Changes in Classification or Limitations. Technical emphasis of a report is indicated by asterisks preceding descriptors. An entry is made more specific by modifying words or other designations following the descriptors. An analyst may be contacted for further information about a report by means of identity through letter codes for office symbol and initials of subject analyst who indexed the report.

The Thesaurus Code Manual contains a compilation of machine codes of descriptors used for subject control of documents in the AD collection. Use-frequency of descriptors is included, also the number of the descriptor group under which each term is listed in the Thesaurus.

State-of-the-art summaries in any given subject field, based on synthesis and interpretation by technical specialists of research information available to ASTIA, form a more comprehensive information service.

A one-hour reply telephone service has been initiated by ASTIA to answer questions on Semiconductor Device applications.

A twenty-four hour answer service has been initiated for questions from engineers and scientists that would involve less than 200 citations.

A cooperative system for providing exchange of current data has been projected.

Civilian organizations must have on file with ASTIA a Field-of-Interest Register approved by their sponsoring military agency for the contract cited, before requesting documents from ASTIA.

ASTIA uses the following equipment:

Remington Rand Solid State 90 computer
Magnetic tape typewriters
Card punch
Synchro-tape machines
Microfilm readers & printers
Sorters
High-speed printers

ASTIA publishes the following:

1. Thesaurus of ASTIA Descriptors, Second Edition (first revision), December 1962.
2. ASTIA Chemical Thesaurus, December 1962
3. Technical Abstract Bulletins (TABs)
4. Key Word in Context (KWIC) Index
5. Interservice Data Exchange Program (IDEP) material-Test Reports on Missile Rocket and Spacecraft Components
6. Production of Bibliographies
7. Secret Technical Abstract Bulletin
8. Thesaurus Code Manual

Additionally, microfilm services are given for unclassified-unlimited technical reports. Results of literature searches conducted in response to individual requests are made available as photocopy booklets to ASTIA users.

Recent and continuing conferences have been and are being held at ASTIA to devise special retrieval vocabularies, called "microthesauri" for deep indexing and rapid retrieval of information in selected subject areas. The basic objective of the Microthesaurus Project is to supplement the recently published revised Thesaurus of ASTIA Descriptors. With the scope of the Thesaurus including all of science and technology, such broad coverage often makes it impossible to provide deep indexing for specific retrieval in narrow scientific areas. Although there is vocabulary control, the descriptors used often have relevance to very broad scientific disciplines. This deficiency would be improved by the microthesauri. Conferences held thus far concerned subject areas of Radiobiology, Semiconductor Devices, Lasers and Masers, Infrared and Ultraviolet Detection, Refractory Metals, Oceanography, Plasma Physics, Biological Warfare, Rocket Motors, and Bionics.

APPENDIX VII

BOEING COMPANY, WICHITA, KANSAS

The Boeing Company, Wichita, Kansas, has conducted research on a mechanized data storage and retrieval system for the storage of information on magnetic memory tapes. The scientific information chosen for storage was from MIL-HDBK-5 which is largely in the form of tables and graphs. Materials and Properties are the major classifying groups which form the ordinate and abscissa of a "two-dimensional Dewey Decimal" system. The work was performed under Contract No. AF 33(616)-8036 to the Aeronautical Systems Division, Directorate of Materials and Processes, Wright-Patterson AFB, Ohio. Military Handbook MIL-HDBK-5, "Strength of Metal Aircraft Elements", is an authoritative source for allowable stresses and other related properties of materials and structural elements.

A materials code was chosen for materials in MIL-HDBK-5. The system was designed to permit the addition of materials as desired or as data became available. Due to the interest in plastics, elastomers, and ceramics as structural materials, work was done to classify these materials. The category numbering system devised, established the identity of a material. The category number covered the atomic number of the element or the primary constituent of the alloy, alloy within each atomic number group, form, condition, thickness itself (no code), and basis (1 - metals, 2 - non-metals). The property coding had eight major groupings; identification (category number), industrial properties, chemical and surface properties, structural properties, mechanical properties, thermal properties, electromagnetic properties, joints and miscellaneous structures. The system was open-ended, i.e., materials, alloys, forms, or conditions could be added and new numbers assigned to identify the new data. Mathematical curve-fitting techniques were applied to fatigue and stress-strain curves.

The IBM 709 or 7090 data processing system used for the program included the components:

IBM 709 central processing unit or
IBM 7100 central processing unit,
IBM 738 or 7302 core storage,
IBM 729I, 729II or 729IV magnetic tape units,
IBM 755 tape control for each channel (709 system),
IBM 766 data synchronizer or 7607 data channel,
IBM 716 printer,

Off line equipment

759 card reader control and
714 card reader or IBM 1401 DPS
757 printer control and 717 printer or IBM 1401 processing system.

Share 7090 symbolic (SOS) language was used in writing the program. Variable information processing package (VIPP) subroutines were used for purposes of input, output and data handling.

APPENDIX VIII

LIBRARY OF CONGRESS

The Library of Congress is one of three U. S. Government libraries engaged as a center for the collection, storage, and dissemination of scientific and technological materials, documents, and other related information. The other two are the National Library of Medicine and the Department of Agriculture Library.

Acquisition of much material is through world-wide exchange agreements with governments, private research centers, libraries, universities, and other scientific and technical institutions. There are standing orders with approximately 750 book dealers throughout the world to provide publications of importance regardless of language or country of origin. Through the copyright function which the Library performs, American scientific publications and many of the foreign ones that are registered for copyright, are obtained.

The Science and Technology Division serves as a collecting and reference center for unclassified technical report literature of the United States and foreign countries. A good part of this literature is from many of the Government agencies and their contractors, including the Atomic Energy Commission, the National Aeronautics and Space Administration, and agencies within the Department of Defense. Reference services are provided to the Congress, to other Government agencies, to other offices of the library, and to the public. The Division has a competent professional staff to handle inquiries of a specialized nature. A special science reading room is maintained on a 7-days-a-week basis. There is a research program in documentation techniques to make the science collections and the reference and bibliographic products as responsive as possible to current trends and needs.

The Library performs a cataloging and indexing service on the materials received. The printed catalog cards are used by the major research libraries throughout the country. Nearly 10,000 subscribers receive the service on the system of subject classification and the printed cards.

Technical correspondence and other records generated internally in the course of answering inquiries in the field of science and technology, comprise a reference correspondence file. The research work embodied in completing responses to inquiries is taken advantage of, when inquiries are repeated on the same subjects, by an indexing control for retrieval using the "Termatrix" device. An index form serves as a work record and cover-sheet for copies of the correspondence or other pertinent documents. Index terms, selected

from an established list of about 150 key terms and 200 code letters, are recorded on each index form. Some code letters are used in combination with key terms to designate ideas not adequately characterized by key terms alone. Terminology authority is maintained by listing the ideas included under each key term, and showing how the more specific ideas are distinguished by the code letters. The addition of new key terms is intentionally kept low. Index numbers are assigned serially as each record form is completed. Index cards are filed by term.

"Termatrix" indexing equipment provides a means for drilling holes in the appropriate subject bakelite card at precise positions to indicate the number assigned to the document pertaining to that particular subject. The model of the device used has a capacity for indexing 40,000 documents on one set of cards, each card being approximately 18 inches square. Correlation is effected using the peek-a-boo method. Records are identified by their index number.

The index can be entered by name of inquirer, author, affiliation of inquirer, country or language, staff member responsible for each record, subject and date. Index entries per item average about 12, about 5 of which are used to characterize the technical subject content. When searching, the combination of key terms and/or code letters, which are used to designate the desired subject, are determined by consulting the terminology authority list. Terms per question average about three. Search of file is by random access. The search time is about three minutes.

Loan records are on punched cards. Files maintained are (1) control file, (2) borrower's account file, (3) central charge file, and statistical analyses file. Punched cards are interfiled manually and matching is performed manually. Machine listing has been found to be especially effective and economical for long lists of overdue material.

A central visible card file record is maintained showing the Library's holdings of serial publications (publications issued in successive parts). The IBM punched cards are used in the preparation of New Series Titles - Classified Subject Arrangement publications.

A number of large-scale projects provide analyses, abstracts, and other bibliographic services on certain types of literature, including scientific and technical material. Much of this work is available through the facilities of the Office of Technical Services of the Department of Commerce.

A photoduplication service provides means for researchers and others to secure photocopies of materials in the Library's collections which might otherwise not be available, and provides this service at an economical level. An electrostatic photoreproduction process, xerography, is used. The equipment is Xerox Copy-flo No. 1. Microfilm is processed on automatic equipment.

The following publications are monthly: "New Series Titles - Classed Subject Arrangement" listing periodicals received, "Monthly Index to Russian Accessions", "East European Accessions Index", and the "Southern Asia Accessions List". Articles on science and technology are listed in a separate section with many subject subdivisions.

A National Union Catalog is maintained which locates research materials in 700 cooperating libraries. It contains around 15 million cards. There are monthly and quarterly issues and annual volumes. It is valuable as a bibliographic tool and as an aid in acquisitions, cataloging, and interlibrary loan work. A quinquennial edition of the National Union Catalog, 1958-1962, will be released in 1963. This cumulation will contain approximately 800,000 cataloged entries and 3,300,000 locations for a total of approximately 1,300,000 cards in 54 volumes. There will be three quarterly issues plus annual volumes of "Library of Congress Catalog - Books: Subjects, 1963". Also available are the "Library of Congress Catalog - Motion Pictures and Filmstrips", in three quarterly issues and an annual volume, the "Information Bulletin" (a weekly) covering miscellaneous information which includes news of new Library of Congress publications plus an annual index to the Bulletins, the "Quarterly Journal of Current Acquisitions", and the "Library of Congress Publications in Print".

The Library relies on its printed catalog cards for indexing, abstracting, and retrieving. Users have advised that while current manual procedures may be adequate for simple collection and storage, the Library's abstracting and indexing systems are not completely adequate to meet the needs of the scientific community. Subject headings, chapter headings, and brief topical sublines, do not meet scientists' research requirements for speed and accuracy, or for specific scientific data not indicated by the Library's indexing procedure. There is the need for extending and supplementing traditional library methods, particularly as they relate to science and technology.

A National Referral Center for Science and Technology, has been established as a division of the Library of Congress, supported by the National Science Foundation. This new agency, which opened to public use on a limited operational basis on March 4, 1963, is another activity established to deal with the high-priority and complicated problem of improving utilization of scientific and technical information. The scope of operations envisioned is that of collecting, indexing, listing and identifying the availability of the information requested, in the nearest geographical location to achieve rapid response. The Center functions as a clearinghouse for the information resources of the scientific and technical community. It assists the established services. Technical questions are not answered directly, but instead, are referred to the organizations, institutions, or individuals, within and outside the Government, capable of furnishing the material or information desired. The Center is concerned with potential sources of scientific and technical information; libraries,

information centers, publications, specialized bibliographic and data service, and the activities of Federal Government agencies, industry and even foreign nations in the technical information field.

General guidance is to be provided in directories and guides.